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# FBI Fingerprint Identification Automation Study: AIDS III Evaluation Report

Volume III: Operational Feasibility

November 15, 1980

Prepared for  
U.S. Department of Justice  
Federal Bureau of Investigation  
Through an agreement with  
National Aeronautics and Space Administration  
by  
Jet Propulsion Laboratory  
California Institute of Technology  
Pasadena, California



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and sponsored by the U.S. Department of Justice, Federal Bureau of Investigation,  
through an agreement with the National Aeronautics and Space Administration.



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## ABSTRACT

An evaluation is presented in this volume which, for the purpose of this study, is defined as the adequacy of system design with known functional and performance requirements. The proposed Rockwell International AIDS III card, document and data flow are presented to summarize the concepts involved and the relationships between functions. The analysis and evaluation includes a study of system compatibility, processing rates, search requirements, and response accuracy as well as a consideration of operational components and hardware integration. Operational availability of the system (i.e., the probability that the equipment will be able to perform the function when required) will not be confirmed until specific hardware is identified and empirical data can be obtained. Results of the study indicate that the AIDS III System concept is operationally feasible if production capacity is slightly enhanced, but that operational complexity, hardware intergration, and a lack of conceptual data pertinent to some of the functions are areas of concern. For a synopsis of this entire report, see the Executive Summary in the Compendium (Volume I).

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## SECTION I

### INTRODUCTION

Operational feasibility is defined as the adequacy of system design, process control procedures, and system performance when compared with known functional and performance requirements. This definition is used to distinguish between operational and technical feasibility, which determines whether the existence, status, and development risks of the technologies employed in the system lead to a technically feasible approach.

System design and performance can be considered as either a technical or an operational issue. For the purposes of this evaluation, system design is considered an operational issue. System performance includes issues of accuracy and completeness, of searches and responses, as well as system availability and processing rates.

Process control includes the monitoring of system performance, queues and work flows, to effectively ensure that processing rate requirements are achieved.

#### A. SCOPE/OBJECTIVE

The objective of this AIDS III Subtask was to evaluate the operational feasibility of the AIDS III System Concept developed by Rockwell International.

The January 1980 issue of the Rockwell AIDS III System Concept document (Ref. 1), the Rockwell April - May 1980 response to the data dictionary (which augmented the January 1980 report), and the documents referenced were used as the basis for evaluation. Supplemental briefings received before May 1980 were also used. No additions or changes to the January 1980 system concept except for those in the April - May 1980 addendum are reflected in the evaluation.

#### B. ESSENTIAL ELEMENTS OF THE ANALYSIS

To decide whether or not the AIDS III System is operationally feasible, four basic questions were asked:

- (1) What are the system's functional requirements?
- (2) What are the system's performance requirements?
- (3) Does the system concept meet these requirements?



- (4) Do the designated hardware and software meet these requirements in terms of availability, compatibility and adequacy?

Recognizing the varying levels of the AIDS III system development, and the depth to which some areas of the system have been explored, not all questions could be answered with the same degree of completeness.

## SECTION II

### SUMMARY

While there are concerns regarding final design and implementation, the indications are that the AIDS III System concept is operationally feasible if production capacity is slightly increased. The operational complexity, the status of work station development, the hardware integration of critical functions, and a lack of conceptual support data are the primary areas of concern.

Simulation modeling of the fingerprint card flow indicated that, with the addition of a total of five work stations in four functions, the system will handle 95% of the 1993 work load in less than 3 hours (99.9% within 4 hours). Further analysis indicates, however, that the system is sensitive to volume surges, and functions within the system have a low tolerance for equipment failure. A seven percent increase in the work load will saturate the system at three points. With single unit failures, many of the functions could not handle the projected work load. Since many functions are operating with limited spare capacity, additional stations or overtime will be required to work off backlogs created by equipment failure or increases in volume. The potential film processing backlogs related to uneven workflow as identified by Rockwell must be resolved, since this component is on the critical path in the identification process.

The high volume of data (66,000 messages with 5.1 million bytes of data per hour) and interdependency of the computer subsystems create a complex data network with a single point of control (the System Supervisor). All of the subsystems exhibit some degree of interdependency. If there is a failure or degradation of one subsystem, most of the others will be affected. When the System Supervisor is down or degraded, all functions in AIDS III will be degraded or cease functioning. A properly sized configuration using available computer and storage technology will support AIDS III, but software and hardware configurations still require additional development to ensure that cost-effective and workable computer subsystems are selected.

Since the final computer hardware configuration has not been selected, it was impractical to do a dynamic simulation of the computer subsystems. As an alternative, a summarization and analysis of the operational component/computer subsystem data transfer rates was made in order to scope the computer configuration requirements. Based on the available data, off-the-shelf technology would support the AIDS III System.

Development of a full set of performance requirements as well as a model of the computer data flow is recommended to assist in determining the most effective hardware and software configuration. In addition, since the data base structure and its management is an integral part of the AIDS III and the development and maintenance costs to support the information processes are significant, it is recommended

that a make/buy evaluation of a commercially available general-purpose Data Base Management System (DBMS) be made.

Analysis of the search performance of the Automated Technical Search Pilot System indicates that it performs better (provides a lower miss rate of 5% vs 24%) than the manual technical search system. The search performance of the AIDS II Automated Name Search, compared with the manual system, also indicates that a lower miss rate will be achieved.

The processing of documents was not adequately covered. There were omissions of key processing functions, location of work stations was not discussed, and the number of documents to be returned to the manual system varied greatly from present procedures without explanation. This area was notable for its inconsistency and lack of complete concept development.

An analysis of the AIDS III System showed that by not microfilming the "rush" requests and walking them through the system, these requests could be processed within 30 minutes, thus meeting this requirement.

There is a high degree of operational complexity involved in the Semi-Automatic Fingerprint Reader, fingerprint classification, image comparison, and search review functions. These functions require a concentrated effort, demanding accuracy, knowledge, and reliability throughout the operational day. It is recommended that prototypes of the fingerprint classification, image comparison, and search review terminals be developed and tested prior to making a full commitment to these concepts.

While the Minutiae Master File and Computerized Criminal Name File and Record Files will not generally require new data, they will require file restructuring and conversion when implementing AIDS III. In addition, a major, 15-month effort will be required to convert the 14.5 million fingerprint master cards to microfiche for use in the automatic retrieval system.

Additional development of facility requirements for the AIDS III System is necessary, as the latest AIDS III concept is not fully reflected in the current facilities plan.

Table 2-1 summarizes the areas of study that were evaluated in the operational feasibility task of the AIDS III evaluation study.

Table 2-1. Operational Feasibility Report Summary

AREA OF STUDY	METHODOLOGY EMPLOYED	OBSERVATIONS	IMPLICATIONS
FUNCTIONAL AND PERFORMANCE REQUIREMENTS	ANALYSIS OF ID GUIDELINES AND RELATED DOCUMENTS	<ul style="list-style-type: none"> <li>• THE RATIONALE FOR THE PERFORMANCE REQUIREMENTS AND CONSTRAINTS HAS NOT BEEN ESTABLISHED. SEE SECTION V.</li> </ul>	FUNCTIONAL AND PERFORMANCE REQUIREMENTS COULD NOT BE USED <u>PER SE</u> AS OPERATIONAL FEASIBILITY CRITERIA.
COMPONENT AVAILABILITY	CALCULATION BASED ON MTBF AND MTTR	<ul style="list-style-type: none"> <li>• ESTIMATED AVAILABILITIES ARE BETWEEN 0.988 AND 1.0.</li> </ul>	AT THAT LEVEL, THE AVAILABILITIES DO NOT AFFECT STATIC OR DYNAMIC MODELED PROCESSING CAPACITY.
PRODUCTION CAPACITY	STATIC ANALYSIS <ul style="list-style-type: none"> <li>• CARD PROCESSING COMPONENTS</li> <li>• DOCUMENT PROCESSING COMPONENTS</li> </ul> DYNAMIC ANALYSIS (GPSS) <ul style="list-style-type: none"> <li>• CARD PROCESSING COMPONENTS</li> </ul> SENSITIVITY ANALYSIS	<ul style="list-style-type: none"> <li>• MARGINAL WITHOUT SINGLE-UNIT FAILURES; UNSATISFACTORY WITH SINGLE UNIT FAILURES.</li> <li>• CONCEPT IS INCOMPLETE.               <ul style="list-style-type: none"> <li>• UPDATES TO FILE NOT SPECIFIED</li> </ul> </li> <li>• PORTION SPECIFIED IS ADEQUATE</li> <li>• MEETS ALL RESPONSE TIME REQUIREMENTS WITH FIVE WORK STATIONS ADDED TO FOUR FUNCTIONS.</li> <li>• SENSITIVE TO VOLUME SURGES AND AVAILABILITY OF WORK STATIONS.</li> <li>• SEE VOLUME IV.</li> <li>• INCORPORATED IN DYNAMIC ANALYSIS</li> </ul>	MARGINALLY OPERATIONAL, RE-EVALUATE SYSTEM CONFIGURATION AND ARCHITECTURE TO ELIMINATE POTENTIAL PROBLEMS.  UNKNOWN IMPACT ON THE AIDS III SYSTEM     MARGINALLY OPERATIONAL. IF SUBSYSTEM AVAILABILITY FALLS BELOW 95% (IN TWO CASES), THE SYSTEM WILL SATURATE AND THE BACKLOG WILL GROW.
TRANSPORTATION BETWEEN WORK STATION	STATIC AND DYNAMIC ANALYSIS		

Table 2-1. Operational Feasibility Report Summary (Cont'd)

AREA OF STUDY	METHODOLOGY EMPLOYED	OBSERVATIONS	IMPLICATIONS
COMPUTER CONFIGURATION AND ARCHITECTURE	TECHNICAL EVALUATION	<ul style="list-style-type: none"> <li>• HARDWARE CONFIGURATION AND SOFTWARE PERFORMANCE REQUIREMENTS NOT FULLY SPECIFIED.</li> <li>• COMPUTER DATA TRANSFER RATES WERE NOT SPECIFIED.</li> <li>• A PROPERLY SIZED CONFIGURATION WITH OFF THE SHELF TECHNOLOGY WILL SUPPORT AIDS III. (SEE VOLUME II AND SECTION II-B OF VOLUME III)</li> </ul>	<p>FUNCTIONAL AND PERFORMANCE REQUIREMENTS COULD NOT BE USED <u>PER SE</u> AS OPERATIONAL FEASIBILITY CRITERIA (SEE VOLUME IX)</p> <p>JPL HAS ESTIMATED THESE RATES TO SCOPE THE SUBSYSTEMS (SEE APPENDIX C, VOLUME III).</p>
SEARCH PERFORMANCE	ANALYSIS OF:		
• NAME (SUBJECT)	• AIDS II RESULTS	<ul style="list-style-type: none"> <li>• PERFORMS BETTER THAN THE MANUAL SYSTEM.</li> </ul>	
• FINGERPRINT (TECHNICAL)	• AUTOMATIC TECHNICAL SEARCH PILOT SYSTEM RESULTS	<ul style="list-style-type: none"> <li>• PERFORMS BETTER THAN THE MANUAL SYSTEM.</li> </ul>	
DATA BASE MANAGEMENT	TECHNICAL EVALUATION	<ul style="list-style-type: none"> <li>• A SPECIAL PURPOSE DATA BASE MANAGEMENT SYSTEM (DBMS) IS TO BE DEVELOPED FOR AIDS III.</li> </ul>	THIS APPROACH MAY NOT BE AS COST-EFFECTIVE AS A COMMERCIALY AVAILABLE GENERAL-PURPOSE DBMS AND A MAKE/ BUY ANALYSIS IS RECOMMENDED.
FILE CONVERSIONS	TECHNICAL EVALUATION	<ul style="list-style-type: none"> <li>• THE HIGH RESOLUTION DIGITAL IMAGES GENERATED BY THE TECHNICAL FILE CONVERSION WERE NOT SAVED.</li> <li>• MINUTIAE MASTER FILE, THE COMPUTERIZED CRIMINAL NAME AND RECORD FILES WILL REQUIRE RESTRUCTURING AND REFORMATTING FOR AIDS III.</li> </ul>	<p>REPHOTOGRAPHING OF THE MASTER FINGERPRINT FILE IS REQUIRED FOR AUTOMATIC IMAGE RETRIEVAL.</p> <p>THIS IS A COMPUTER FILE TO COMPUTER FILE CONVERSION AND SHOULD BE STRAIGHT FORWARD.</p>
FACILITIES	TECHNICAL EVALUATION	<ul style="list-style-type: none"> <li>• SPACE REQUIREMENTS NOT CONSISTENT BETWEEN JANUARY 1980 AND MAY 1980 SYSTEM DESCRIPTIONS.</li> <li>• SAFETY AND FIRE PROTECTION REQUIREMENTS INCOMPLETE.</li> </ul>	<p>ADDITIONAL INFORMATION IS REQUIRED FOR ANALYSIS</p> <p>ADDITIONAL INFORMATION IS REQUIRED FOR ANALYSIS.</p>

## SECTION III

### METHODOLOGY

The methodology that was developed and utilized to evaluate AIDS III's operational feasibility is reflected in Figure 3-1 and described below.

#### A. DATA GATHERING

First, the study team gathered system concept design documentation consisting of Rockwell reports, engineering memoranda and similar materials (all references are listed at the end of this volume). The data gathering process included technical discussions with the FBI and Rockwell AIDS III project personnel. Tours of the FBI Identification Division in Washington D.C. were also a source of information.

Specific operational and design data were gathered and documented for each operational component\* of the AIDS III System Concept. This included the five subsystem computer configurations and System Supervisor. Whenever applicable, information in the following areas was collected for each component:

- (1) Description of the component.
- (2) Service rates.
- (3) Number of units proposed.
- (4) Availability.
- (5) Operability.
- (6) Component status.
- (7) Interfaces.
- (8) Search performance and/or accuracy.
- (9) File conversion.
- (10) Design and implementation approach.
- (11) Issues and concerns.

---

\*The term "operational component" refers to an operation or processing step (manual, automatic, computer-aided, or combination thereof) required to perform a specific function.

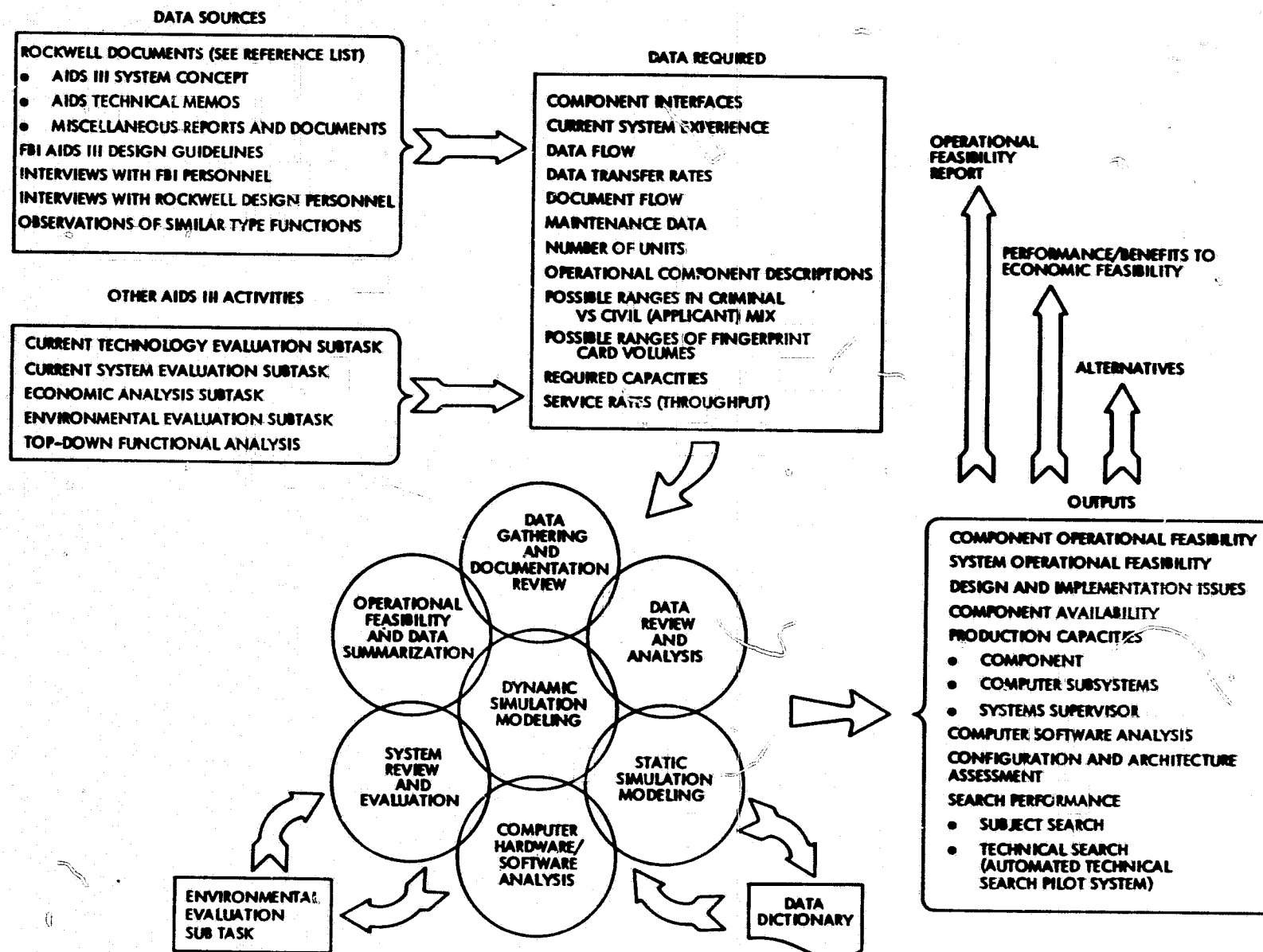


Figure 3-1. Operational Feasibility Evaluation Methodology

Had data been available, the next step would have been the development of functional and performance requirements at the system and subsystem levels. Using these requirements as standards, the design would then have had a basis for comparison in evaluating its adequacy. The fact that the new system improves performance of a particular function is not necessarily a benefit unless the existing system fails to meet the same requirements. This subject is discussed further in Section V.

## **B. STATIC AND DYNAMIC ANALYSIS**

The third major step in establishing operational feasibility of the AIDS III concept was to perform static and dynamic analyses of the system to determine whether it was sufficiently robust to accommodate both changes in work load volume and changes in its mixture (e.g., the ratio of criminal vs civil inquiries).

Based on the data collected, each operational component was statistically analyzed for availability and service rate capabilities. This process identified potential problem areas in the fingerprint card system flow. It also highlighted those components that would fail to meet their throughput requirements as a result of a single unit failure.

The dynamic simulation of the AIDS III system under varying work loads established a more thorough test of its operational feasibility (the static analysis being only a "quick look" technique). A computer based simulation model was developed using General-Purpose Systems Simulation (GPSS) software. Using this high-level simulation language on the Univac 1108 computer, the AIDS III System was modeled to evaluate the system capacity and analyze the concepts of queueing and card flow. The flow of card images for automatic retrieval and verification was also simulated. The lack of sufficient data prohibited the development of a dynamic simulation of the system data flow through the computer.

The model was designed in a parametric manner, allowing the variation of work load volume and criminal/civil card mix. Variations in component service rates and numbers of units was also modeled. The data gathering and analysis activity produced the primary data for the components within the model. System bottlenecks were identified and resolved by increasing the number of service units. Once the baseline model had been established, it was enhanced by JPL to meet the FBI Guidelines.

Throughout the building, testing, and operation of the model, reviews were held to ensure that the model was valid and reflected the AIDS III System Concept. Detailed discussions of the simulation model can be found in Section VI, Paragraph B.

The Environment Analysis (Volume VI of this report) provided work load volume ranges and various mixes of criminal and civil fingerprint cards for sensitivity testing. These work load volumes were entered into the model, and the resulting card throughput was evaluated.



### C. TECHNICAL ANALYSIS

Data transfer requirements for the System Supervisor and each computer subsystem were summarized. Analysis of this information was used in an attempt to evaluate the proposed hardware configuration. Because of the lack of specifics about the final hardware configuration (and some ambiguity in the subsystem functions) the data processing requirements of the AIDS III system could only be analyzed at a conceptual level.

In addition to analyzing each operational component and computer subsystem and developing a simulation model, general areas such as data base management, search performance, system implementation, file conversion, and system work flow control were reviewed and evaluated.

### D. DATA DICTIONARY

The original schedule called for the completion of the operational feasibility evaluation in February, 1980. At that time, however, the subtask realized that there was insufficient data to completely evaluate the AIDS III System Concept. The deficiency was most prevalent in the areas of process control queueing strategy, computer configurations/capacities, data management/handling and system monitoring. The missing data was documented and transmitted to the FBI through the Data Dictionary (see appendix to Volume I). The Data Dictionary indicated the unspecified or insufficiently specified data elements required to complete the AIDS III Operational Feasibility evaluation. It was prepared in matrix format, with the rows reflecting the data elements required and the columns identifying the data needed for each element (i.e., area of data deficiency, data required, its format, and the subtask requiring the data). The additional data received from Rockwell as a result of this effort, plus the data previously gathered, was combined and used as the data base for the Operational Feasibility evaluation.

## SECTION IV

### AIDS III SYSTEM CONCEPT DESCRIPTION

The Rockwell AIDS III card, document, and data flow are presented in this section. The intent is to summarize the concepts involved, to indicate the relationships between functions, and to provide the reader with a basic understanding of each concept. A diagrammatic view is shown in Figure 4-1. The names and abbreviations used throughout this volume were derived from Rockwell's documentation.

Details of the Rockwell AIDS III System Concept are described in their January 1980 document (Ref. 1), the technical memorandum prepared by Rockwell in response to the JPL Data Dictionary (see appendix to Volume I) which augmented the January 1980 report, and related documents. A list of these documents can be found in the Reference List at the end of this volume.

#### A. FINGERPRINT CARD PROCESSING

The fingerprint cards and other documents enter the AIDS III system from the FBI mailroom (MAIL) as shown in Figure 4-2. The mailroom operation consists of opening the mail and separating the fingerprint cards from other documents. Documents are forwarded for processing as described in Section B, Document Processing. The alien registration and personnel identification cards are accumulated throughout the day. At the end of the day they are counted, date stamped for statistical reporting purposes, and logged (DATE STP). They are then classified (CLASS-C) and routed to the civil file with no further interface with the automated system. The criminal and civil (applicant) cards are forwarded for coding with a process control number (PCN). If a criminal/civil priority scheme is needed, the cards are separated at this point.

Rush requests for fingerprint card searches enter the system at the process control number (PCN) function. Processing of these requests is described in Section C, Rush Request Processing.

##### 1. Process Control Number Application

When criminal and civil fingerprint cards arrive at the PCN printers, a unique, machine-readable, dated and sequenced process control number is printed on each card. The process control number is used as the primary accounting index. It is used to maintain an audit trail for associating the data on the card with the processing performed by the system computers.



**Figure 4-1. AIDS III System Overview**

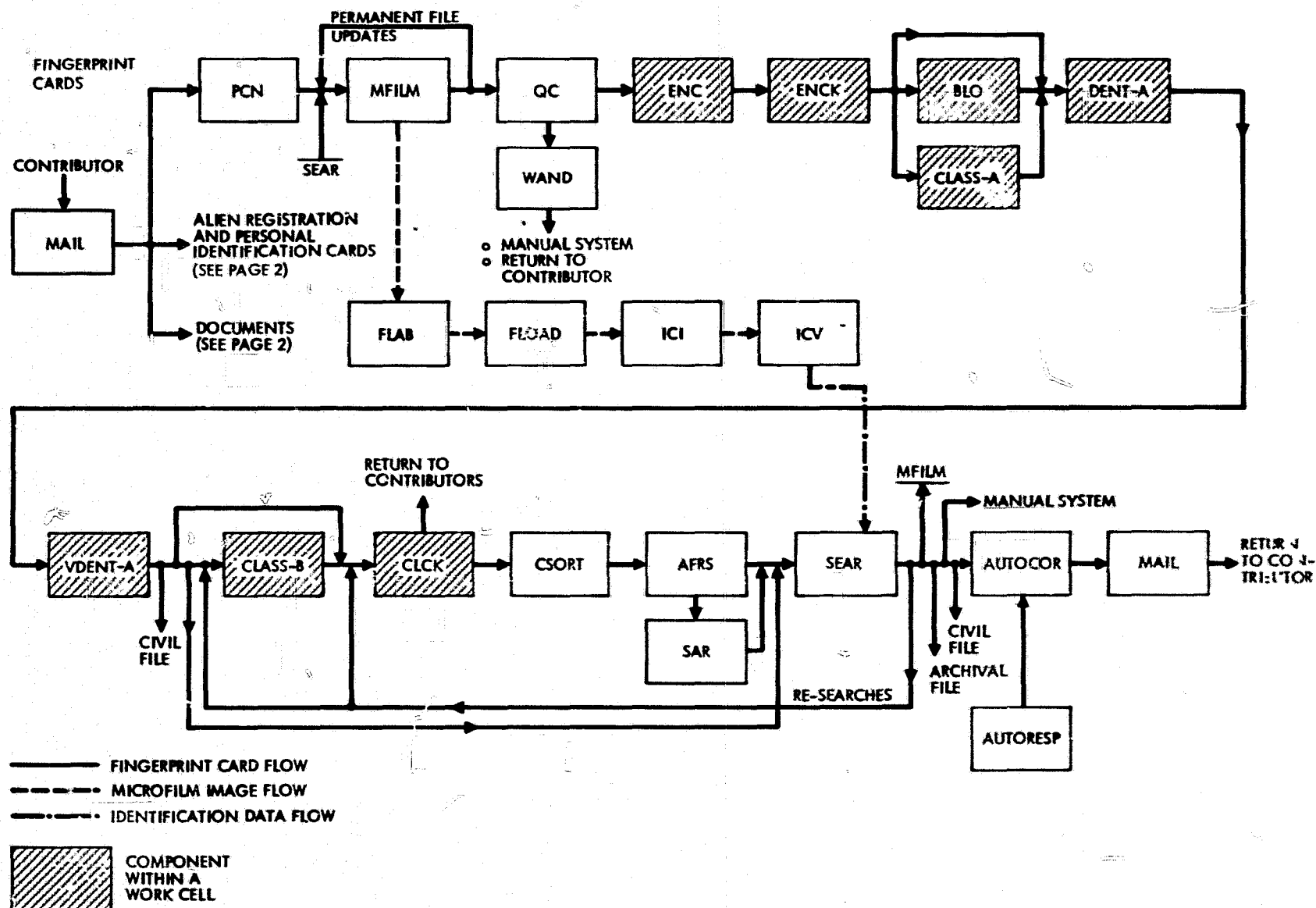


Figure 4-2. Fingerprint Card/Document Flow

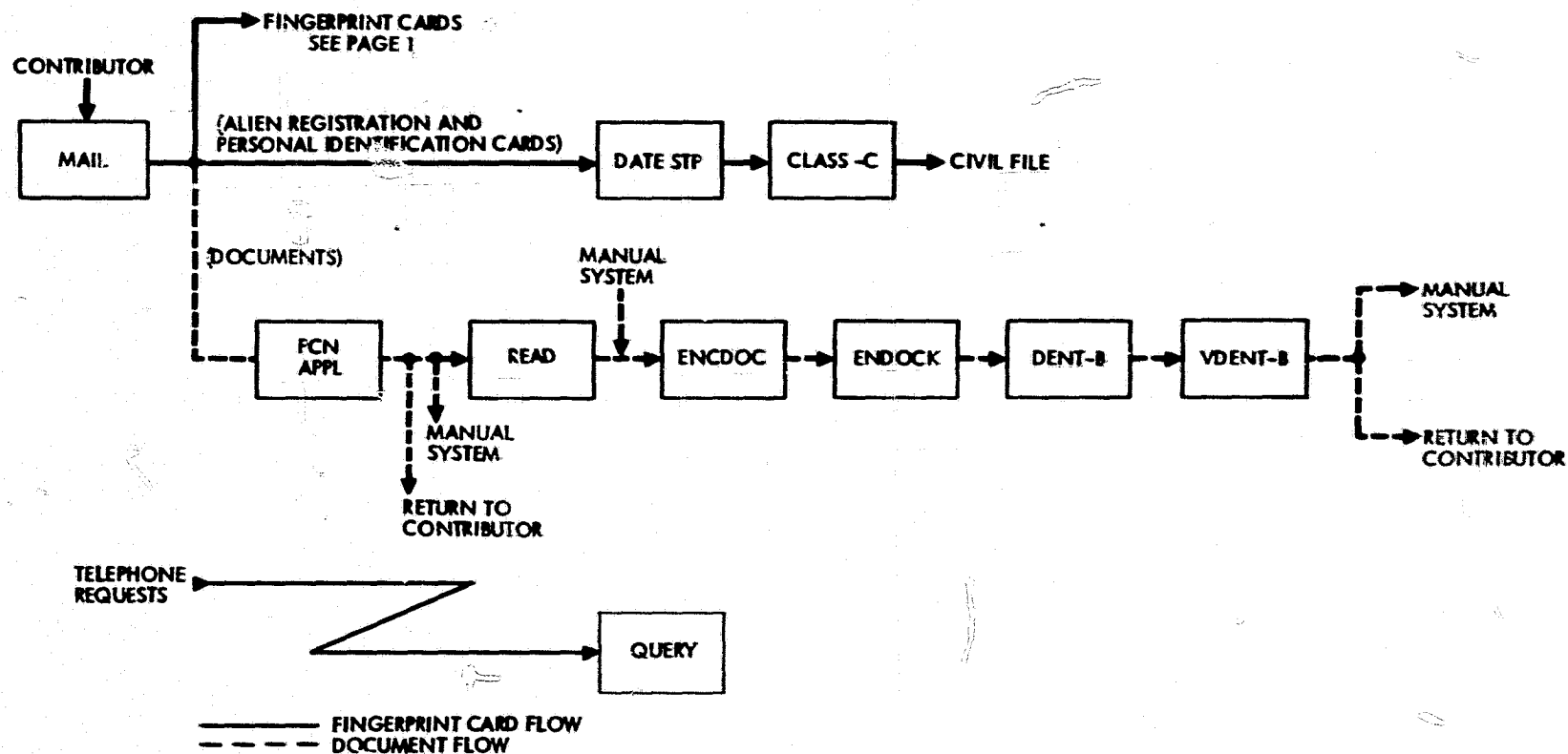


Figure 4-2. Fingerprint Card/Document Flow (Cont'd)

## 2. Microfilm

From the PCN application, the cards move to the microfilm cameras (MFILM) for fingerprint image capture. All cards are filmed, although some may not be used in the image comparison system. The objective is to convert cards into film images as soon as possible in order to minimize the impact of film processing delay on response time. Cards designated for temporary file update and for permanent file update are also sent to the microfilm cameras.

Roll film from the cameras is processed (FLAB) and converted into ultramicrofiche. Two copies of each fiche are generated for each of the 19 image comparison and 13 verification terminals. The microfiche are distributed (FLOAD) to the image comparison identification and verification (ICI and ICV) terminals.

## 3. Quality Check

After the fingerprint cards are filmed (MFILM), they are routed for a quality check (QC) and a separation of those cards to be removed from the AIDS III automated processing system. Cards are removed from automated processing when:

- (1) Necessary information is missing - returned to contributor.
- (2) Year of birth is less than the Automated Subject Search cutoff year (1958) - sent to the manual system.
- (3) Card has a non-AIDS FBI number - sent to the manual system.
- (4) Card has only four fingers - sent to the manual system.

Also entering the QC function are cards returned from the manual system which were originally received with a non-AIDS FBI number, or were not identified (non-idents) in the manual system and are being resubmitted for an automated search. Cards that do not continue in the automated process are passed from quality control (QC) to wand out\* (WAND) and removed from the system. Contributor data and status designation are recorded with a data entry keyboard which allows the system to retain contributor and work load statistics while monitoring card status.

## 4. Encoding and Encode Check

Most of the cards are passed from QC to the encoding function (ENC), where data input formats are checked and criminal arrest data are encoded. Also entering the encoding function are cards for AIDS subjects that were: 1) identified in the manual system and now being

---

\*The PCN is read with an optical character reader (OCR) wand.

returned for file update and response generation in the automated system; 2) not identified in the manual name search (Card Index Section) and now being returned for automated technical search, or 3) not identified in the manual fingerprint search and now being added to the automated technical search Minutiae Master File.

All cards leaving the encoding function (ENC) are passed to encoding check (ENCK) for an independent verification of the encoded data. The cards are then separated by type into separate processing streams.

#### 5. Data Entry, Blocking Out and Classification

Cards with an AIDS FBI number (either contributor-supplied or through the manual identification process) are routed directly to data entry (DENT-A). The remaining cards must receive a fingerprint classification before the automated subject search. Criminal cards are sent to blocking out (BLO), where a high-level, Henry classification is performed. The BLO function also flags criminal prints which are probably illegible, so that arrest data are not entered in the data entry process.

At the classification function (CLASS-A), civil, regular military and Coast Guard cards from ENCK receive full NCIC fingerprint classification. Civil cards receive full classification because most (90%) of the cards are not identified in subject search and ultimately require full classification prior to automated technical search. Military and Coast Guard cards receive full classification as required by the civil file. At the time of full classification, the data are entered into the system using special data entry terminals which complement the classification function (finger block display layout similar to the fingerprint card, and single purpose keys representing finger classification symbols). The finger classification is also written on the card.

At the data entry work station (DENT-A), subject search parameters and arrest data are entered into the system and held for verification. At the data entry verification function (VDENT-A) the data are checked, character-by-character. After the subject search parameters are verified, the search is initiated. While the search takes place, the arrest data are verified. The results of the computer subject search (i.e., whether a candidate has been identified) are indicated on the CRT terminal screen to inform the VDENT-A operator of proper routing of the card as follows:

- (1) Criminal cards with no candidates to classification (CLASS-B).
- (2) Civil cards with no candidates to classification check (CLOCK).
- (3) Cards with candidates to search review (SEAR).
- (4) Military with no candidates to the civil file.

Criminal cards that had candidates from subject search but were not identified and verified when checked against the fingerprint card are returned from SEAR for a technical search and are also sent to the classification function (CLASS-B).

After classification, all cards are processed in the classification check function (CLOCK) using the same type of terminal used in classification. This function verifies the classification previously made. In checking, the stored classification is recalled to a CRT display using the PCN. If necessary, changes are made and legible cards are routed to centerline sort (CSORT). Those cards determined to be illegible are removed from the process and sent to automated correspondence (AUTOCOR) to be returned to the contributors.

Also sent to CLOCK are civil cards with no subject search candidates, and those civil cards that had non-identification candidates from subject search but were not positively identified by fingerprint check. These cards were fully classified (CLASS-A) prior to subject search, and therefore bypass the classification process (CLASS-B) of the criminal cards. The classification check of civil cards is similar to, but less extensive than, that for criminal cards.

## 6. Fingerprint Reading

At CSORT, the cards are inspected to determine the approximate centerlines. The prints may vary from high to low in each of the fingerprint boxes and some portions may even be outside the boxes. The cards are sorted into groups having the same centerline, and are routed in batches to the Automatic Fingerprint Reader System (AFRS) for minutiae extraction. Based on the fingerprint minutiae data from AFRS, together with the classification data and other descriptive information previously entered into the system, the automated technical search is initiated.

Those cards rejected by the AFRS require computer-aided, manual minutiae encoding on the Semi-Automatic Reader (SAR). The computer saves all the AFRS data on rejected cards so that only prints of the rejected fingers need to be manually encoded. When the rejected conditions are corrected at the SAR operation, automated technical search for the card can proceed. A very few cards may have fingerprints that cannot be successfully reconstructed by the SAR terminal (designated as rejects to be returned to the contributor). Following the AFRS and SAR operations, the fingerprint cards are routed to the search review function (SEAR).

## 7. Image Comparison

The microfiche fingerprint images for the automated technical and subject search candidates are available to the image comparison identification (ICI) and verification (ICV) functions. Here the identification process is performed using microfiche images rather than actual fingerprint cards. These functions are under computer



control and are initiated when two conditions are satisfied. First, the fingerprint image of the inquiry search card in microfiche format is displayed on the image comparison terminal. Secondly, a candidate list from either the automated subject or technical search function is available. All image comparison terminals receive a copy of all inquiry search images so that any terminal (each one of which has access to only a segment of the master fingerprint image file) can make comparisons with file subjects in its particular segment.

When the above conditions are satisfied, search candidates are reviewed (ICI) to determine tentative candidates by either the automated subject or technical search. This is accomplished by comparing current search fingerprint images (received on microfiche) with master file microfiche images. The retrieval of all images is under computer control. Tentative identifications are designated by the operator to be reviewed by an image comparison verification operator (ICV). Searches with no tentative identifications are designated as such and bypass the verification step. Results of the image comparison are then available at search review (SEAR).

## 8. Search Review

Search review (SEAR) reviews all fingerprint cards except those previously removed because of poor quality or illegibility, and military cards with no subject search candidates. SEAR performs two functions: search process evaluation and card routing. As the cards arrive at SEAR, the PCN is entered into the system and the search results are displayed on a CRT terminal. For process evaluation, SEAR provides the final measure of quality control: the final human acceptance of no identifications based on automated search results.

Those searches that have been designated as identifications by image comparison (ICI/ICV) require no further decisions, and the search results (displayed on the console CRT) indicate the proper card routing. Some fingerprint cards are returned to the contributors per their request, and the remainder are retained in original hard copy form. A few are returned to the manual system for file update.

Inquiry cards designated as subject search candidates but which were not positively identified by image comparison (ICI/ICV) are routed to the classification function (CLASS-B) for preparation for an automated technical search. Those cards with contributor-supplied FBI numbers that were not identified require a subject search. This is initiated by SEAR without routing of the card because all necessary data have been entered. These cards are set aside awaiting search results and subsequently handled the same as cards with or without subject search candidates.

Searches designated as automated technical search with no identifications undergo a process evaluation wherein the SEAR operator, having a display of search results and search conditions and a detailed understanding of the search process, decides if a second search should be performed using different search arguments or characteristics.

If the inquiry search card is a new criminal addition to the file, an FBI number is assigned to that card at SEAR. The new criminal cards to be retained are routed back to image capture (MFILM) for temporary image file additions on a daily basis. Temporary file additions are similar to current work, since each image comparison terminal receives duplicate copies. Permanent file additions occur when enough (approximately 2000) additions accumulate to fill a microfiche sheet for a single segment of the file. Following permanent microfiche image file additions, the cards are filed (some civil cards are routed to the civil file for retention).

#### 9. Response Generation

The automated response generation (AUTORESP) and automated correspondence, (AUTOCOR) functions are the remaining functions in fingerprint search processing. These functions are concerned with the accumulation and sending of data to the contributor.

Responses are run on high-speed line printers in batches to allow the grouping of responses to the same contributor for reduced postage costs. The printed responses are generated at AUTORESP and sent to AUTOCOR for assembly. The high-speed printers at AUTORESP also produce name index cards to update the CARD Index name file for AIDS subjects prior to 1961.

AUTOCOR associates responses with those cards to be returned to the contributor and submits the envelopes to the mailroom for stamping and mailing.

#### B. DOCUMENT PROCESSING

The processing of documents (i.e., dispositions and miscellaneous requests) is reflected in Figure 4-2 (page 2). In the mailroom (MAIL) the documents are separated from the fingerprint cards and sent to have a process control number assigned (PCN APPL). Since documents are of various sizes, the process control number assigned (PCN) is applied with a simple sequential number stamp either by hand or an electrically driven stamp triggered by document insertion.

Following the PCN APPL function, the documents are routed to a quality control and sorting function (READ). At READ, the documents are reviewed, checked for quality and annotated. The dispositions are separated and sent for encoding (ENCDOC). The various remaining forms and letters are read, and the required processing is determined before encoding. All documents are subjected to a quality control review to assure that information for data entry (DENT-B) is correct. A few requests are separated for processing in the manual system or returned to the sender because no action is required or possible.

At the ENCDOC function, the search and disposition data to be used for updating of the automated files are prepared for data entry (DENT-B). The encoding is then verified (ENDOCK), prior to data

entry, and sent to VDENT-B for data entry verification and initiation of a subject search. Identifications are determined based on the information available from the criminal history files. No fingerprint comparisons are attempted for these documents. Data entry is verified (VDENT-B) and the appropriate action is initiated. Further activities related to documents have not been specified at this time. The current system includes: 1) for identifications, files are updated with the appropriate data or response outputs are initiated for record requests and 2) for no identifications, a response is initiated as appropriate. All documents are now sent to the manual system for disposition or returned to the sender.

#### C. RUSH REQUEST PROCESSING

Rush requests are those that are hand-carried through the system to obtain the shortest possible response time. Some rush requests require card searches, and some are merely requests for records when no fingerprints are available.

Rush requests achieve the quickest response time when the card is hand carried to each function in the process. As the card is presented at each station, the operator is expected to finish the card currently in process and accept the rush request as the next item of work. The entire process allows a rush request to be handled in an estimated 30 minutes, and should not disrupt the normal work load if rush request percentage volumes are comparable to those currently experienced.

Requests for records requiring immediate action or telephone query are handled at the on-line query function (QUERY) as shown in Figure 4-2. This function through an on-line data entry terminal has access to the criminal history files. A hard copy of the records can be obtained using on-line printers.

#### D. COMPUTER DATA PROCESSING

All card routing and data flow are under the control of the System Supervisor, as are all data that flow between the various computer subsystems. The subsystems do not interface directly with each other but rather through the Systems Supervisor as reflected in Figure 4-3. The key control data element is the process control number (PCN) which is assigned to each fingerprint card and document as it enters the system. The PCN is the audit and control identifier of a card through its processing in AIDS III. After the PCN number has been assigned and is recorded by the System Supervisor (SS) in the Master Transaction Record (MTR) and Transaction Record (TR) files, the card is processed as described in Paragraph A above. At each function that interfaces with a computer, the PCN number is recorded and an indicator is placed in the MTR as to the last location of that card.

During the capture of the fingerprint card image on microfilm (MFILM), and subsequent development of that image (FLAB), the roll and

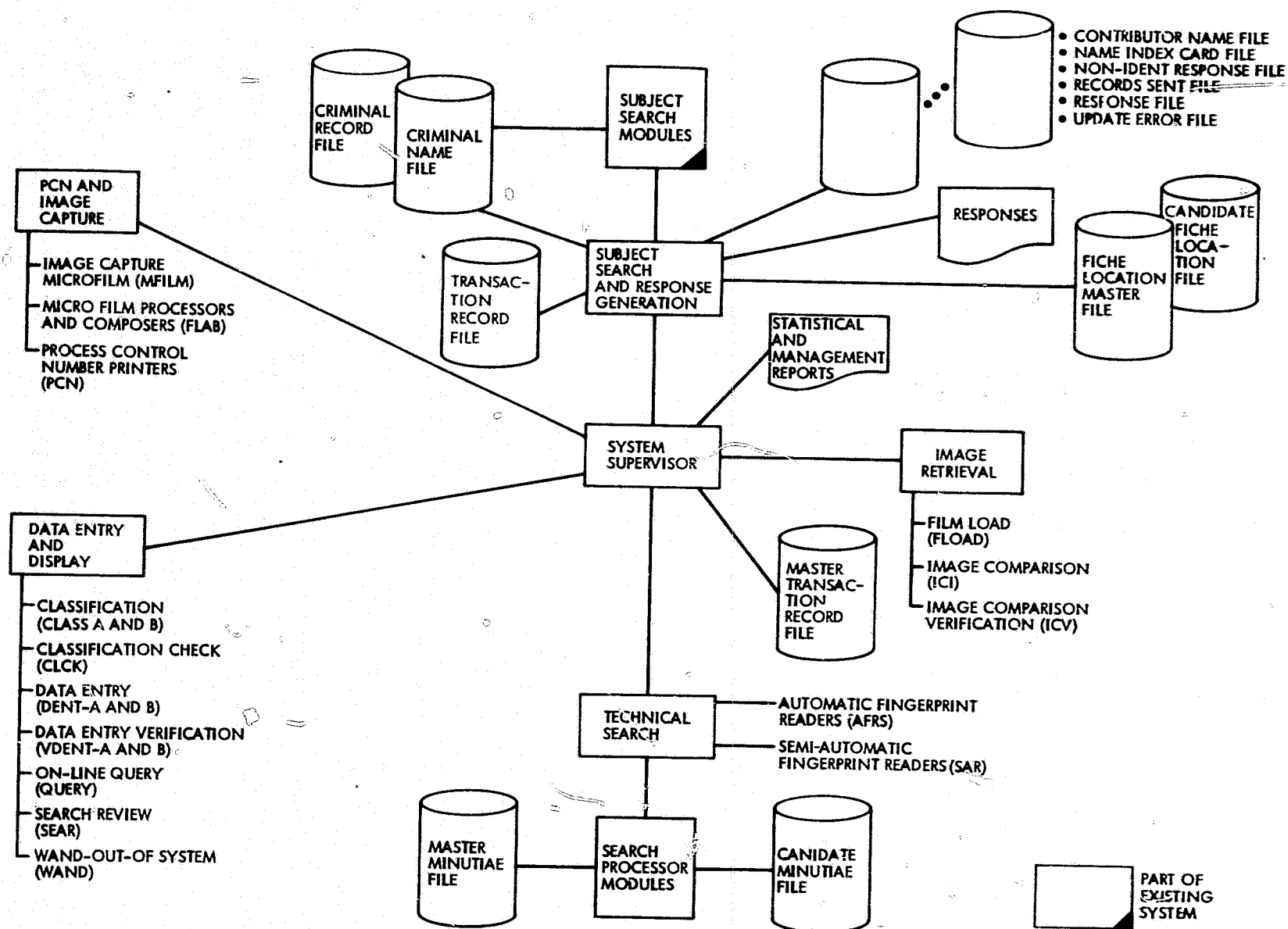


Figure 4-3. Subsystem Interfaces

microfiche location of the image is fed to the system and stored in the TR file. The data captured at the classification functions (CLASS A, B, and CLCK) are also stored in the TR.

After the search parameters are entered and verified (DENT-A/B and VDENT-A/B), they are passed through the Data Entry and Display (DEDS) subsystem to the System Supervisor which initiates, through the Subject Search and Response Generation (SSRG) subsystem, a subject search. The result of that subject search is passed back to the System Supervisor, and then to the data entry verification (VDENT-A or VDENT-B) operator to direct the operator in the proper routing of the card/document. The search data and the arrest information that have been captured during the data input process are stored by the SSRG subsystem in the TR file awaiting dispositive response from search review (SEAR). Those fingerprint cards with no subject search candidates are routed to the Automatic Fingerprint Reader System (AFRS) where the fingerprints are read and the minutiae data are captured. The minutiae data are processed against the Minutiae Master File (MMF) in the Technical Search (TSS) subsystem. If a candidate is located during the technical search, this information is then passed back through the TSS and Systems Supervisor to the SSRG subsystem.

The list of candidates that has been generated as a result of either a subject search or a technical search is forwarded to the SSRG subsystem. Using the FBI number, the SSRG looks up the associated microfiche location and forwards these data to the Image Comparison (ICS) subsystem. In the ICS, the appropriate microfiche for the search inquiry card and candidate fingerprint image are selected from the microfiche file. At the image comparison identification (ICI) function, the image of the search inquiry card is placed on one screen while the candidate card image, under computer control, is displayed on a second screen. If there is more than one candidate, and the first is a non-ident, the system automatically presents the next candidate microfiche image to the ICI operator. The operator, upon making positive identification, notifies the system. The identification is then verified at the image comparison verification function (ICV). Once an identification or non-identification has been made, this information is directed to the System Supervisor and placed in the MTR.

Once the fingerprint cards themselves have reached the search review (SEAR) function, the operator checks the MTR file and reviews the search results. If a positive identification is made, the SEAR operator instructs the system to generate an appropriate response and update the related files. The process control number is cleared from the system. If an identification has not been made, the SEAR operator can initiate a second search based on modified search criteria or (if it is a criminal inquiry card) assign it an FBI number to establish it as a new master card in the basic fingerprint file.

The Management Report Generation and System Simulation (MRGSS) Task is part of the System Supervisor. Different files (hardware status, PCNs, Manpower, etc.) are assessed and information contained

in these files is used to create Management Reports. This set of files will provide a mechanism for data collection, report generation and system performance monitoring.

A software simulator which models the system operation will be used for predicting work load volumes at the various functions including variations in input volumes, unavailable components, or other dynamic portions of the system. This simulation is inclusive down to the component level (i.e., the effect of removing a single component can be evaluated). The simulator package will access many of the same files utilized for the management report.

## SECTION V

### FUNCTIONAL AND PERFORMANCE REQUIREMENTS

#### A. DEFINITIONS

Four phrases used in this section may require definition.

- (1) Functional requirement.
- (2) Performance requirement.
- (3) Top-down functional analysis.
- (4) Measure of effectiveness.

Functional requirements are the collective capabilities that a system and its subsystem must possess to fulfill the users' objectives. Functional requirements are not design characteristics. They simply indicate to the designer the capabilities that must be available in the system.

Performance requirements describe the level of quality with which each function must be accomplished. Consequently, performance requirements are generally quantifiable and can, as such, be measured.

The determination of the functional requirements of a system can be accomplished in more than one way. An extremely effective method is top-down functional analysis (see Reference 21 for a TDFA of the FBI's Identification Division). This method starts at the highest level objective and systematically identifies all functions needed to reach that goal. When the complete set of functions supporting the objective has been identified, each of the functions is in turn subdivided into subfunctions until the lowest useful level is reached.

Measures of effectiveness (MOE) are the parameters used to gauge the state and performance of a system in achieving its goals. They are used as a source of performance requirements, since performance requirements are essential to measures of effectiveness.

#### B. METHODOLOGY OF REQUIREMENTS DEVELOPMENT

The development of functional requirements is illustrated in Figure 5-1. First, a TDFA is performed. This analysis divides objectives and functions of the Identification Division into increasingly more detailed subfunctions until further breakdowns become so design-dependent as to be unusable. Functions that are candidates for automation are identified. Those functions that were automated by AIDS I and II are marked in Reference 21, as well as those which are to be automated by AIDS III.

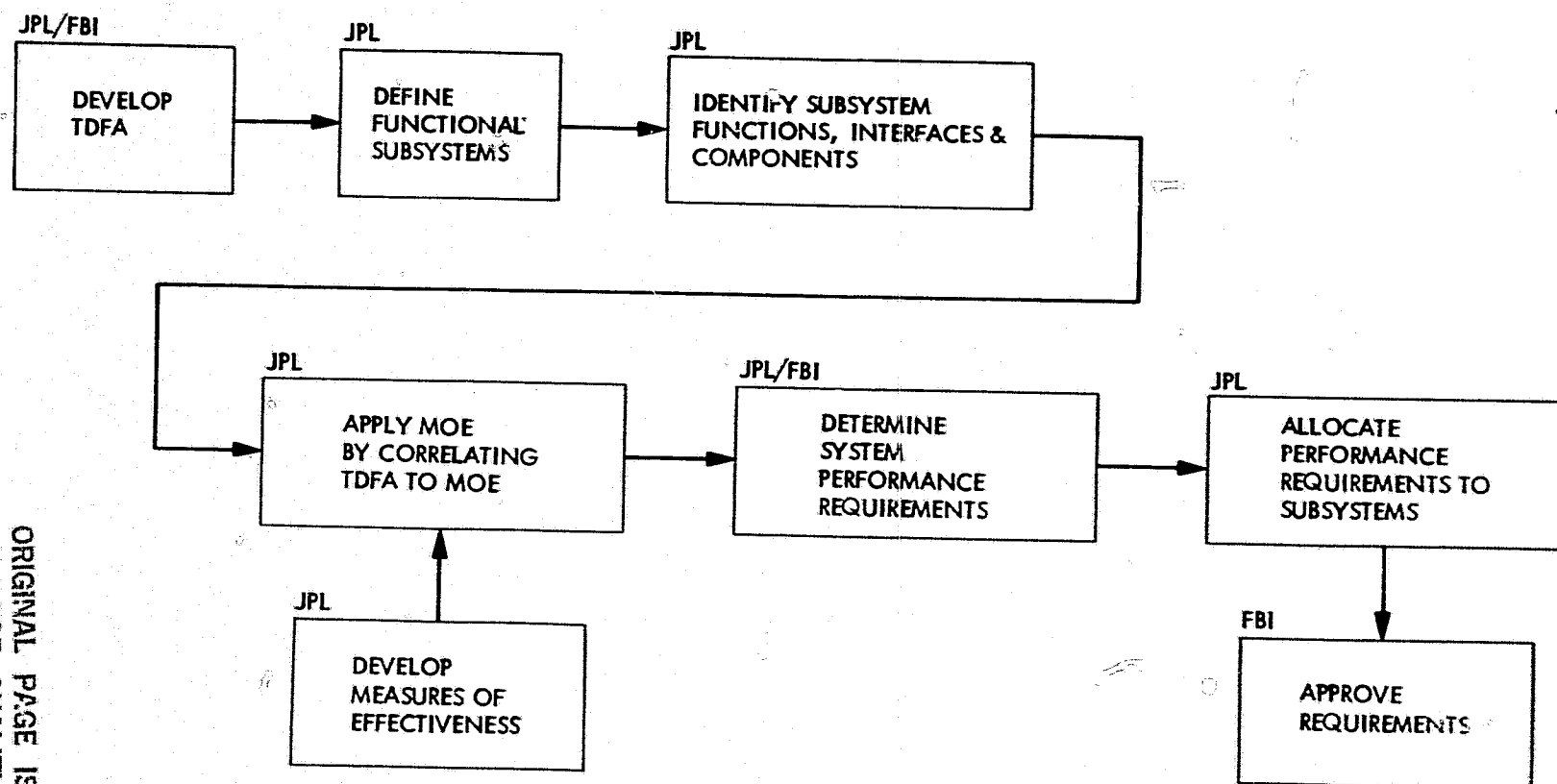


Figure 5-1. Functional Requirements Development



A functional design is then created that requires subsystem identification. Next, interfaces between subsystems are defined, as well as specific functions and major components such as data files.

In parallel with these steps, MOE are developed. The MOE are then related to the functional system design by correlating them to the functions of the TDFA by subsystem.

The next step requires the involvement of the FBI, since the designer cannot know the importance of search accuracy or response speed without consulting the operators and sponsors of the system. After determining system performance requirements, the engineers can assign functions to appropriate subsystems, leading to a complete set of system and subsystem functional requirements. These requirements can be communicated to the builders with assurance that the system will accommodate the necessary functions, all interfaces will be properly designed, and the system will respond and perform as intended.

### C. EVALUATION OF ESTABLISHED REQUIREMENTS

The FBI has stated system requirements in two documents: the Work Requirements Statement (Reference 31) and the Design Guidelines (Reference 23). Since each of the specific AIDS objectives in the Work Requirements Statement is repeated and often detailed further in the Design Guidelines, the latter document was used as a source. Footnotes indicated below and in Tables 5-1 through 5-5 refer to paragraphs in the Design Guidelines document (Reference 23).

The guidelines were arranged in categories and each category was evaluated separately. The five categories selected were as follows.

#### 1. System Objectives

System objectives were those statements indicating overall benefits that should be obtained through the automated system. They were too general to apply to the measurement of operational feasibility against functional requirements. They are paraphrased for brevity in Table 5-1 and discussed in more detail in Volume 1.

#### 2. Design Guidelines

The guidelines determine the system designer's development strategies (see Table 5-2). Reference paragraphs numbers 2 through 12 are specific to the AIDS III evaluation and will not apply to the evaluation of alternative systems.

These design guidelines strongly influence evaluation of the system feasibility in terms of design approach. They are generally considered appropriate except for "3-byte minutiae storage and matching," which may unnecessarily constrain the system designers.

Table 5-1. System Objectives

Reference Paragraph	System Objectives
1-a	Achieve cost savings
1-b	Improve quality of service
7	Minimize and schedule overtime in advance
10	Hardware procurement; not to be based upon suggested configuration during evaluation phase

Table 5-2. Design Guidelines

Reference Paragraph	Design Guidelines
1-f	Nondisruptive implementation
1-h	Parallel running of automated and manual systems to allow for file conversion
2	Semi-automatic classification system not to preclude future automatic system
3	Manual fingerprint card retrieval system acceptable
12	3-byte minutiae storage and matching
14	System based upon available technology
16	Modular design for work load variations

### 3. System Constraints

System constraints are externally imposed and thus dictate the system environment. They define the boundaries of a working area within which a technically, operationally and economically feasible solution must be found to establish system feasibility. Consequently, constraints are used with both functional and performance requirements (discussed below). Constraints are paraphrased for brevity in Table 5-3.

### 4. Functional and Performance Requirements

The remaining tables (5-4 and 5-5) briefly paraphrase the functional and performance requirements identified in the Design Guidelines document. The performance requirements refer to performance levels that must be met either by the system, a subsystem, or a specific component. Since these performance requirements provide the quantitative basis for judging the operational feasibility of the AIDS III design concept, a discussion of each item follows:

- (1) Reference Paragraph 1-c. This statement refers to the degree of accuracy that must be achieved by the system. The allowable miss rate for false or wrong identifications is zero. This requirement will not change when alternatives are evaluated. There is, however, an allowable miss rate for "missed" identifications. For the AIDS III evaluation, the requirement is that the new system perform better than the existing manual system in making identifications. This performance base is established in JPL Document 5030-457, Volume V, Current System Evaluation. This level of accuracy may need quantifying on an absolute scale for the evaluation of alternatives.
- (2) Reference Paragraph 4. This statement defines the permanent storage requirement for the Subject Search, Technical Search, and Identification/Verification Subsystems.
- (3) Reference Paragraph 8. This statement defines the projected work load that must be handled by the Identification Division system. The volume is used to determine the temporary storage capacity for the Subject Search, Technical Search, and Identification/Verification Subsystems as well as the interface capacity requirement for the system and subsystems (see Appendix I for discussion of work load value discrepancies).
- (4) Reference Paragraph 9. The performance requirements in the Identification Division guidelines sometimes seemed too stringent, particularly in the case of the 8-hour response time for 95% of the fingerprint cards. This requirement did not appear to be based on a clearly

Table 5-3. System Constraints

Reference Paragraph	System Constraints
1-i	Remain within current Identification Division space allocation
1-j	Fingerprint card to remain unchanged
5	Workday to be 18 hr/day, 5 days/week for routine processing; 24 hr/day, 7 days/week to expedite processing
6	Staffing to be at a ratio of 2 to 1, day shift to night shift
13	No more than 5 AFRS

Table 5-4. Functional Requirements

Reference Paragraph	Functional Requirements
1-d	Preserve or improve the integrity and security of data
1-e	Preserve existing legal and accountability features
1-g	Subsystems to be tested separately before large-scale implementation
1-k	Support the National Crime Information Center Computerized Criminal History program
1-l	Not to preclude latent fingerprint search
1-m	Not to preclude alternative methods for data transmission between origin and Identification Division

Table 5-5. Performance Requirements Evaluation

Reference Paragraph	Requirement	MOE Area	Remarks
1-c	Improve fingerprint identification accuracy	Accuracy	Requirement relative to current system
4	Automated Subject Search to handle 14.5 million records; Automated Technical Search (ATS) to handle 14-26 million records	Permanent storage capacity	Adequately defined
8	Work load to be 1973 actuals plus 25%	Temporary storage capacity	Adequately defined
9	Response time routine/ expedite to be: 0.95 probable for 8 hr/30 min 0.99 probable for 48 hr/8 hrs 0.999 probable for 96 hr	Response time	Adjust if necessary to satisfy other requirements
11	ATS; based on minutiae and equal to or better than M-41 Matcher	Accuracy	Qualitative; applies only to AIDS III evaluation
15	ATS CPU requirements (8 sec/ search)	Response time	Based on capability of an obsolete class of computer
15	AFRS cards read/hr (210)	Response time	Rate of 250 used. Based on JPL Study and projected 50% increase based on AFRS modification proposed by Rockwell
15	AFRS Availability (95%)	Availability	98.82% based on JPL study

identifiable need. It has been agreed between JPL and the Identification Division that the requirements stated in the guidelines would remain until it was shown that no operationally feasible solution existed. For example, if the 8-hour, 5-reader (AFRS) one and one-half shift constraints excluded any feasible solution, then the Identification Division would relax these boundaries. A more substantial solution will be sought during the evaluation of alternative systems (second phase). Consequently, these numbers are to be used as a set of initial parameters with which to test system performance, and not as strict performance requirements to be met in determining operational feasibility of the design concept.

- (5) Reference Paragraph 11. This statement refers again to the level of accuracy necessary for AIDS III design concept operational feasibility. This requirement is sufficient for the AIDS III evaluation final report, but may require quantifying on an absolute scale for the evaluation of alternatives.
- (6) Reference Paragraph 15. This item lists performance levels that have been projected for AIDS III components.
  - (a) The CPU requirement for a technical search based upon an IBM 360/65 employs an obsolete class of computers.
  - (b) The AFRS throughput rate is discussed in Appendix F of this volume.
  - (c) The AFRS availability is discussed in Section VII.

## SECTION VI

### OPERATIONAL CAPACITY

The FBI Identification Division AIDS III Guidelines (Reference 28) state that the ability of the overall system shall be sufficient to provide:

- (1) a 0.95 probability of processing each of the cards/documents in the design work load within 8 work hours for the routine work load and 30 minutes for expedite requests;
- (2) a 0.99 probability of processing the design work load within 48 work hours for routine work, and within 8 hours for expedite requests; and
- (3) a 0.999 probability of processing the design work load within 96 work hours for routine work.

The processing time is the time it takes a card or document to travel between the mail room input at the beginning of the process and the mail room output at the end of the process.

To determine the feasibility of the AIDS III System Concept in meeting these guidelines, a dynamic simulation model of the system's card processing flow was developed on the UNIVAC 1108 computer using the General-Purpose Simulation System (GPSS). The results of the initial simulation, using service rates and the number of servers proposed in the AIDS III System Concept, indicated that the AIDS III system would not process the Guidelines volume of 29,177 fingerprint cards per day. However, with a total increase of five work stations in four functions, the following results were achieved:

- (1) 95.0% of the cards were processed within 2.9 work hours.
- (2) 99.0% of the cards were processed within 3.0 work hours.
- (3) 99.9% of the cards were processed within 3.8 work hours.

An analysis of the AIDS III system indicated that, by not microfilming each fingerprint card and walking it through the system, "rush" requests could be processed within 30 minutes.

The simulation model was only developed for the card processing portion of AIDS III. The application of a static analysis to the document processing components indicated that the number of units proposed would handle the work load. However, all functions relating to the processing of documents were not addressed. In addition, the location of the work stations was not described in the Rockwell documents, and the number of documents to be retrieved for the manual system varied greatly from present operations without explanation (see Appendix I).

Since the final hardware configuration has not been selected, it was not practical to do a thorough static capacity analysis of the computer subsystems. As an alternative, a summarization and analysis of the operational component/computer subsystem data transfer requirements were made. Based on the data available, it is felt that if the configuration proposed is properly sized (i.e., sufficient processing rates, memory and storage capacity) and utilizes currently available technology, it will support the AIDS III system. The development of an effective networking structure and the utilization of a responsive data base management system will be the keys to effectively using the hardware/software selected.

#### A. OPERATIONAL COMPONENT AVAILABILITY

The development of operational component availability utilizing Mean-Time-Between-Failure and Mean-Time-To-Restore data did not materially affect the throughput capability of the various functions (see Section VII). However, when the effect of a single unit failure on the capability of an operational component was analyzed, a significant number of functions showed negative or marginal ability to handle the projected work load on a stand alone basis. Those operational components reflecting a near zero or negative spare capacity are of particular concern and are summarized in Table 6-1. A detailed chart on the availability of all operational components can be found in Appendix B, Static Capacity Evaluation of Operational Components.

#### B. STATIC ANALYSIS

The static analysis of operational components indicates that the operational components have marginal spare capacity when operating at 100% of estimated throughput capacity. It is questionable whether the components have sufficient resilience to deal with short-term surges caused by increased card input volumes.

When all units of a component are functioning, there is a very small capacity margin in the following card processing functions: automated correspondence (AUTOCOR), centerline sort (CSORT), quality control (QC) classification (CLASS A and B) and encoding related functions ENC and ENCK (see Table 6-1). The fifteen work cells proposed will just handle the projected work volumes.

The spare capacity of N-1 units indicates the impact of a single unit failure within a component. Under this condition, most functions will be performed below the capacity required to support the estimated volumes, while other units will perform marginally (see Table 6-1). This marginal production capacity is of concern in functions with a small number of units, such as the Automatic Fingerprint Reader Systems (AFRS), image comparison and verification (ICI and ICV), Semi-Automatic Readers (SAR) and search review (SEAR). The SAR function is of specific concern.



Table 6-1. Component Capability - Static Analysis

Operational Components		Proposed Units (N)	% Spare Capacity of N Units	% Spare Capacity of N-1 Units
Acronym	Description			
AFRS	Automated Fingerprint Reader System			
	@ 165 CPH (JPL Measurement)	5	-20.1	-36.1
	@ 250 CPH (Proposed Enhancement)	5	21.0	-3.2
AUTOCOR	Automated Correspondence	25	3.7	-0.4
CLASS-A	Classification-A	8*	6.7	-6.7
CLASS B	Classification-B	3*	15.4	-23.1
CLCK	Classification Check	3*	53.4	2.2
CSORT	Centerline Sort	12	4.5	-4.2
DENT-A	Data Entry A-Cards	6*	20.0	0.0
DENT-B	Date Entry B-Documents	42	3.3	0.8
ENC	Encode-Cards	2*	6.7	-46.7
ENDOC	Encode-Documents	17	4.5	-1.6
FLAB	Film Processing	2	104.7	2.3
ICI	Image Comparison Identification	19	10.9	5.1
ICV	Image Comparison Verification	13	15.7	6.8
MAIL	Open Mail and Sort	6	11.3	-7.3
MFILM	Image Capture on Microfilm	6	18.5	-1.2
PCN	Process Control Number	2	63.3	-18.3
PCN APPL	Process Control Number-Documents	1	0.0	-100.0
QC	Quality Control	14	2.9	-4.5

Table 6-1. Component Capability - Static Analysis (cont'd)

Operational Components		Proposed Units (N)	% Spare Capacity of N Units	% Spare Capacity of N-1 Units
Acronym	Description			
QUERY	ON-Line Query	1	40.6	-100.0
READ	Quality Control-Documents	11	2.3	-7.0
SAR	Semi-Automatic Reader	7	16.7	0.0
SEAR	Search Review	15	14.1	6.5
VDENT-A	Data Entry Verification-A-Cards	6*	20.0	0.0
VDENT-B	Data Entry Verification-B-Documents	42	3.3	0.8
WAND	Wand Out of System	5	55.0	24.0
--	Work Cell	15	0.0	-6.5

\*Per work cell (i.e., would reduce the capability of a single work cell by the percent noted)

A very small increase of poor quality prints (e.g., 5 per hour) can overload the capability of this function. The estimate is that 3% of the cards entering the AFRS will require processing through the SAR function. If this percentage increases to 5%, the SARs will not handle the increased load and will have a backlog of 16 cards per hour (the equivalent of 3.2 work stations). The number of rejected cards will depend on two primary conditions: 1) the quality of the cards received, and 2) the performance of the AFRSs.

In general, the analysis indicates that the system is sized with a narrow margin. When one unit fails and is not repaired or replaced, the system will not be able to handle the work load. Because of the marginal capability of many functions, work backlogs that develop during a failure cannot be expected to be alleviated immediately when the unit is replaced. This backlog may require overtime or additional equipment.

The maintenance policy proposed by Rockwell assumes that sufficient space, terminals and parts will be available for replacement in the event of failure (See Section VII, Paragraph A.). This is particularly significant for those functions identified above as being marginal. In addition, the estimated one-hour response time for a trouble or failure report must be reduced in these marginal areas. If the system is to maintain its throughput goals and keep overtime to a minimum, these marginal areas must be given close attention.

### C. AIDS III SYSTEM DYNAMIC SIMULATION

#### 1. Description of Simulation Model Results

When the AIDS III design was simulated using estimated 1993 input and the number of work stations designated, utilizations of 1.0 occurred at Quality Control (QC), Centerline Sort (CSORT), Semi-automatic Reader (SAR) and Automated Correspondence (AUTOCOR). When utilizations are 1.0, the system will never stabilize and queues will grow without limit. However, the overloads at the station mentioned above were small, and the addition of one work station to QC, CSORT, and SAR and two work stations to AUTOCOR was sufficient to reduce utilization to below .95.

With added stations, the system was simulated successfully with the following throughput times:

<u>Fraction</u>	<u>Upper Limit</u>
0.999	3.8 hours
0.990	3.0 hours
0.950	2.9 hours

Table 6-2 compares the number of stations in the Rockwell AIDS III design with the minimum number of work stations required to successfully stabilize a simulated run.

The analysis also indicated that the system is sensitive to volume surges and has a low margin of spare capacity to handle equipment failures. As a result, either additional work stations or overtime will be required to work off backlogs created by the degradation of an up-line function or an increase in volume.

## 2. Simulation Model Queuing Concepts

An item in a queuing system generally spends its time either receiving service or waiting in line to receive service. The total time spent in the system is the sum of all of the wait times plus all of the service times (ignoring, for the moment, such factors as transportation times between stations or delays while sitting in an output hopper). Service times for AIDS III are well defined and are, in general, quite short. With the exception of the time required to process microfilm and the service time for the SAR work station (which only a small fraction of the prints enter), the sum of average service times through the AIDS III stations does not exceed 20 minutes.

Virtually all of the functions of the AIDS III system are served by multi-server queues. One line feeds each function, and the transaction of the head of the line can be handled by any of a number of servers. The average wait time to receive service from a multi-server queue is given by the following formula\*:

$$\text{average wait time} = \frac{B}{M} \times \frac{ts}{1-P}$$

where  $M$  = the number of servers

$B$  = the probability that all  $M$  servers are busy

$ts$  = the average service time

$P$  = utilization =  $\frac{\text{input volume} \times ts}{M}$

The average wait time (in units of service time) is shown in Table 6-3 for 5, 10, 15, and 20 servers at various levels of utilization.

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\* Assumptions:

1. Poisson arrival pattern
2. Exponential service times
3. All servers equally loaded
5. First-in, first-out dispatching
6. No items leave the queue

Table 6-2. Comparison of AIDS III Design and Minimal Number of Work Stations for Successful Simulation

Acronym	Description	AIDS III Design	Minimum Number_
AFRS	Automatic Fingerprint Reader System	5	5
AUTOCOR	Automated Correspondence	22	24
CSORT	Centerline Sort	12	13
ICI	Image Comparison Identification	19	19
ICV	Image Comparison Verification	13	13
MFILM	Image Capture Micro-film	5	5
PCN	Process Control Number Application-Cards	2	2
QC	Quality Control Check	14	15
SAR	Semi-Automatic Fingerprint Reader	7	8
SEAR	Search Review	15	15
WAND	Wand Out of System	5	5
-	Work Cell	15	15

Table 6-3. Average Wait Time (in Units of Service Time)

$\rho$	NUMBER OF SERVERS			
	5	10	15	20
.4	.02	--	--	--
.5	.05	.01	--	--
.6	.12	.03	.01	--
.7	.25	.07	.03	.02
.8	.55	.21	.11	.06
.9	.76	.67	.40	.28
.95	3.5	1.7	1.1	.76
.98	9.5	4.6	3.0	2.3

Table 6-3 is used as follows: given a work station with 15 servers, a utilization of 0.9, and an average service time of twenty seconds, what is the average wait time to receive service? Table 6-3 shows that the average wait time for 15 servers with utilization of 0.9 is four-tenths of a service time or, in this case, 8 seconds ( $0.4 \times 20 = 8$ ). It is important to note that, even with only five servers (if average utilization is kept at or below 0.95), wait times will not exceed three-and-a-half times the average. As the number of servers increase (and utilization is held constant) the average wait time decreases.

Most of the work stations in the AIDS III design have several servers and, in general, wait times can be expected to be a maximum of four times the average service time. Since the sum of average service times is generally less than 20 minutes, it would be reasonable to expect that total average wait plus service times would be somewhat under two hours. However, note that if average input exceeds the capacity of the servers, utilization will be 1.0 (the servers will always be busy). In this situation, the system will never stabilize; average queue length and average wait time for service will grow without limit. The rate at which they grow will depend on the extent to which input exceeds capacity.

With several servers and utilization less than or equal to 0.95, wait times are reasonably short. With a utilization of 1.0, the average wait time approaches infinity. With several servers, performance degrades from very good to unworkable within the narrow band of utilization from approximately 0.95 to 1.0\*. Thus, a system designed to run at a high rate of utilization (given the assumptions stated earlier for the wait time equation) is sensitive to increases in input. Even a small temporary increase in input could result in an average utilization of 1.0. If this occurred at any station, the system would be unstable and average queue lengths would start to grow indefinitely. If the system input were underestimated by a relatively small amount in the design stage, an inherently unstable system would be the result. The important concept is that the system tends to either work very well or not at all. If a given AIDS III work station is underdesigned by three servers, then adding two servers will not really improve the system. It will slow the rate at which the queues build, but they will still grow indefinitely. Adding all three servers, however, will generally improve performance to well within AIDS guidelines. This fundamental understanding that AIDS III will either work well within these guidelines or not at all was instrumental in designing the simulation model.

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\*In Table 6-3, with 5 servers, a change in utilization from 0.8 to 0.9 results in a change in average wait time of from 0.55 to 0.76 service times - an increase of approximately 38%. A change in utilization from 0.9 to 0.98 results in an average change of from 0.76 to 9.5 service times - an increase of 1150%.

### 3. System Simulation Simplifying Assumptions

The General Purpose Simulation System (GPSS) uses transactions which are moved through the system according to the programmed conditions. The fingerprint cards represent transactions in this simulation. A GPSS can only tolerate a limited number of active transactions at one time. As the number of transactions increases, the cost and time required for simulation increase dramatically. Because of the large volume to be handled, it was quickly apparent that one transaction could not represent a single fingerprint card, but must represent a group of cards. This idea of batching introduced its own problems. If one transaction represents ten prints, service times must be multiplied by ten. This causes average wait times and average total times in the system to be multiplied by ten. Another problem aggravated by the batch size is system stability. When the simulation starts, the system is empty. The first several transactions move easily through the system, without queuing causing a bias in the statistics. To overcome this, the system is run until it is reasonably stable. Then the statistics are reset (all transactions are left in the system), and the simulation is run for an additional period of time. The larger the batch size, the longer the system has to be run to be confident that the system is stable. Thus, the savings achieved by allowing one transaction to represent several prints is at least partially offset by the need to simulate the system for longer periods of time in order to achieve stability. Runs with batch sizes of 1, 2, 5, 10, 25, 50, and 100 were attempted. The runs with batches of 1, 2, 5, and 10 took inordinately long, and 25 was selected as the smallest practical batch size.

In determining the number of days to run each simulation, the determining factor was the number of queues at each station. Ideally, the system should be run until average queue length stabilizes. For most runs, it was found that the queues appeared to be stable after approximately three days of simulation. Statistics were then reset, and the system was simulated an additional three days in order to gather the desired statistics.

To keep the simulation within reason, several aspects of AIDS had to be simplified. Rather than simulate microfilm processing, it was decided to merely delay entry of a transaction into the ICI work station until a standard processing time had elapsed. Rockwell AIDS Technical Memo 80-008J lists a total processing time for microfilm (1000 frames/reel) of 159.7 minutes. No transaction was permitted to enter the ICI station until it was held for at least 159.7 minutes.

Transportation was another aspect of AIDS III that was simplified. In most cases, output from the work station is placed on a belt moving at a rate of 100 feet/minute. In many instances, the distance to the next station is trivial (as in the work cells). It was found to be more practical to simply omit transportation time for simulation runs.

Each work shift was simulated to have a productive period of 7.5 hours. Since the second shift is staffed at only half the level of the first shift, this had to be reflected in the model. Thus, two-thirds of the transactions are generated during the first shift. Rather than reduce the number of servers during the second shift, it was simpler to double the service time. This achieved the same effect since it halved the output of the second shift. The work cells were treated differently, since they were represented by individual blocks. During the evening shift, transactions were routed only to half of the work cell blocks (rounded higher when necessary). Transactions remaining in the other blocks at the end of the first shift were allowed to complete processing through the cell.

A certain fraction of input is sent to the manual system from the WAND station. A portion of these transactions returns to the AIDS III system. The time spent in the manual system is not included in the simulation, nor is it included in the throughput calculations for AIDS III. It was not simulated because the time involved (days) was not defined and was totally out of scale with the rest of the AIDS III functions (minutes).

Treatment of the work cells required simplification. Initial attempts at accurately simulating the entire AIDS III system with all stations were not feasible, because the GPSS model was incapable of simulating such a large number of transactions. One work cell was modeled as a separate model. This was successfully done, and provided useful statistics. The problem of how to insert a simplified version of the work cell into the AIDS III model was addressed. This was complicated by what has been described as the "pipeline" effect, which can be illustrated with a few examples.

Suppose there is a system in which there are three serial work stations. Each work station has one server and the service time distribution is exponential, with a mean of 55 seconds. The input to the first work station follows a Poisson pattern with an average arrival rate of 60 per hour. This situation is illustrated in Figure 6-1.



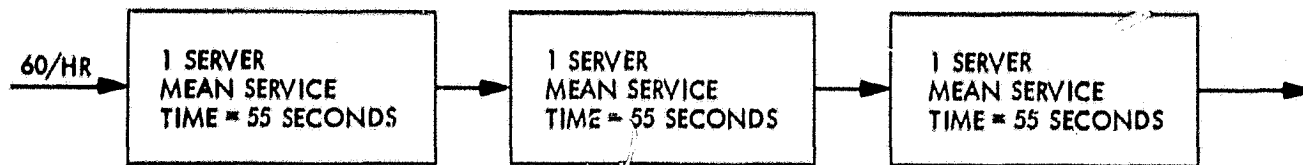


Figure 6-1. Three Serial Work Stations

To simplify this model, an attempt was made to represent it with a single block. To reflect the fact that a transaction goes through three processing steps, the service time was tripled, as in Figure 6-2. A simple simulation of this model showed that the maximum input that could be handled (without utilization reaching 1.0 and an infinite queue buildup) was 21 per hour. Average throughput time was 2570 seconds. Clearly this simplification cannot handle the appropriate volume of input, nor is the throughput accurately represented.

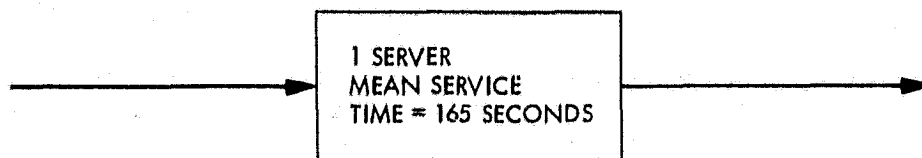


Figure 6-2. Triple Service Time

The next attempt involved tripling the service time, and also tripling the number of servers, as shown in Figure 6-3.

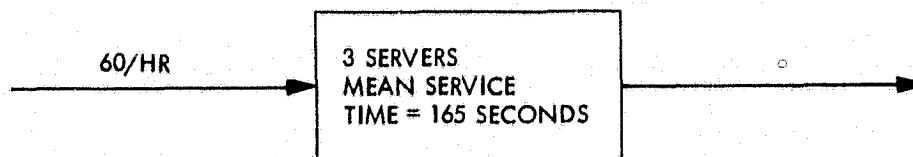


Figure 6-3. Three Servers; Triple Service Time

In this simplification, the benefits of a multi-server queue are obtained and, although the input of sixty per hour can be handled, the average wait time and the average queue length are understated. A simple simulation of this model yielded an average total throughput time of 618 seconds.

It was finally decided to model the first block only as in Figure 6-4.

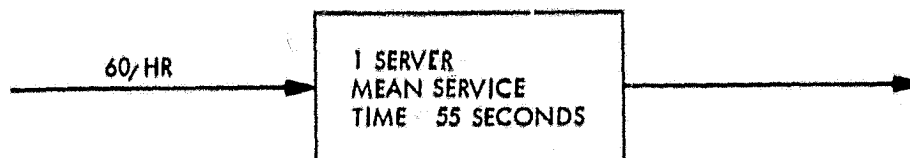


Figure 6-4. First Block Only Modeled.

A simple simulation of this model indicated a total average throughput time of 411 seconds. While this clearly understates the average throughput time, the average queue length in front of the block will be correct. In the case of the AIDS III model, since the work cell was modeled separately, throughput times are well known. By allowing the work cells in the AIDS III model to be represented by single blocks, the mechanics of card distribution and queueing within the work cell is accurately simulated. The understated throughput time can later be added as a constant. Table 6-4 provides a comparison of the original three-stage system and the three attempts to simplify it.

#### 4. Work Cell Simulation

When the attempt to simulate the entire AIDS III concept failed (due to inadequate capacity in GPSS), it was decided to simulate the work cell separately. Once the characteristics of the work cell were understood, it was possible to replace each work cell in the AIDS III model with a single block. This simplification permitted the AIDS III model to run successfully.

A schematic diagram of one work cell is shown in Figure 6-5. The upper left-hand corner of each block gives the number of servers for the function. The upper right-hand corner gives the service time in seconds and the service time distribution (E=exponential). At the extreme left is the average hourly input of 156 (one-fifteenth of the total hourly input to all work cells). The small numbers on the lines indicate the fractions of output from a given function when the output can follow more than one path.

The work cell model was simulated successfully for a period of twelve days.

Table 6-4. Comparison of Attempts to Simplify 3-Stage System

NO. OF WORK STATIONS	NO. SERVERS PER WORK STATION	SERVICE TIME PER WORK STATION	INPUT/OUTPUT RATE	AVERAGE TOTAL THROUGHPUT TIME	REMARKS
3	1	55 SECONDS	60/HR	1521 SECONDS	1. ORIGINAL SYSTEM
1	1	165 SECONDS	21/HR	2570 SECONDS	1. MAXIMUM INPUT/OUTPUT GREATLY REDUCED 2. TOTAL AVERAGE THROUGHPUT TIME GREATLY INCREASED 3. AVERAGE QUEUE LENGTH MUCH LONGER
1	3	165 SECONDS	60/HR	618 SECONDS	1. TOTAL AVERAGE THROUGHPUT TIME GREATLY REDUCED 2. AVERAGE QUEUE LENGTH INCORRECT
1	1	55 SECONDS	60/HR	411 SECONDS	1. TOTAL AVERAGE THROUGHPUT TIME GREATLY REDUCED 2. AVERAGE QUEUE LENGTH CORRECT

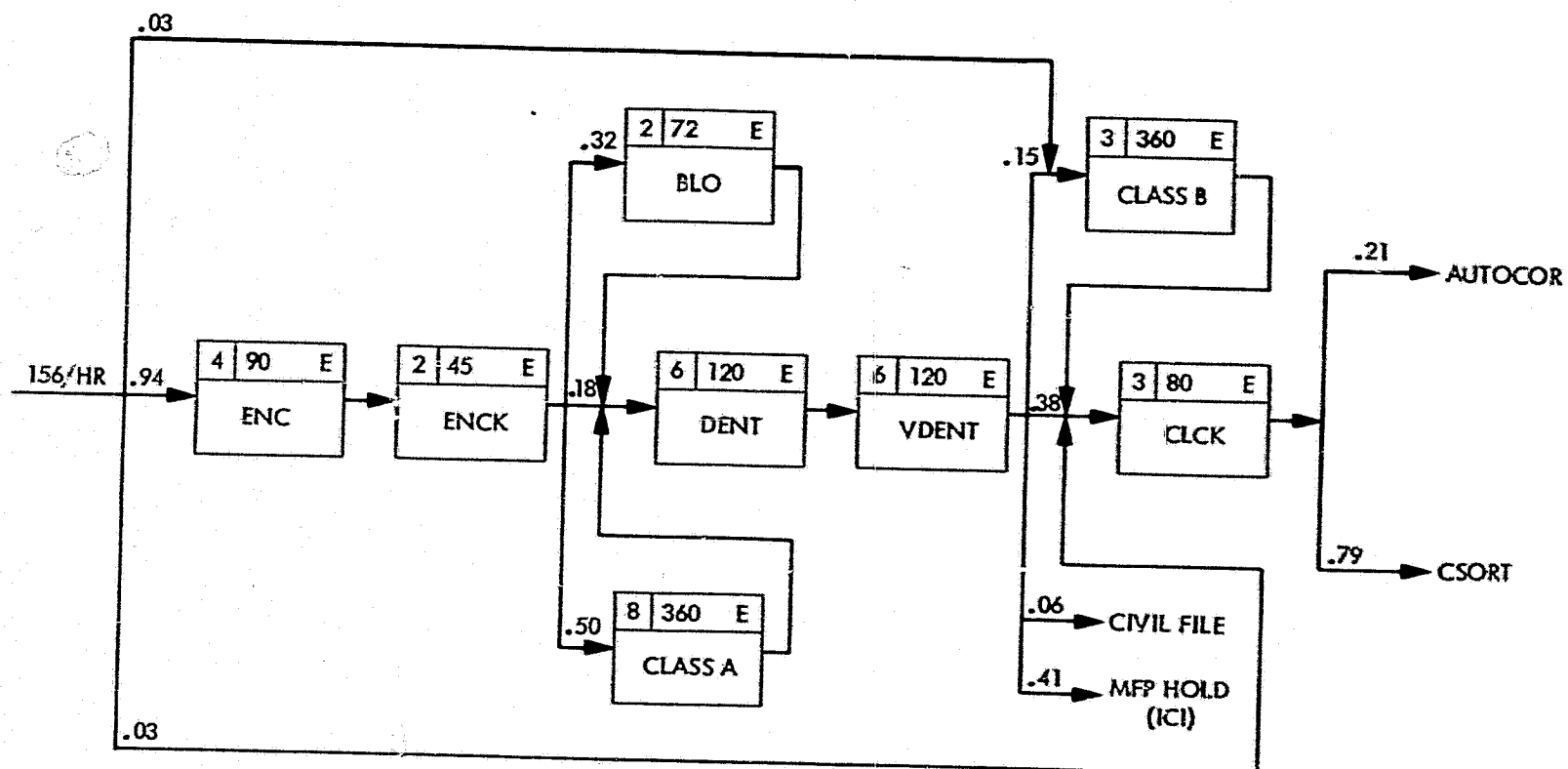


Figure 6-5. Work Cell Model

The average throughput times for prints going to civil files or image comparisons (MFP hold) was 15.8 minutes. The average throughput times for prints going to automated correspondence (AUTOCOR) or centerline sort (CSORT) was 21.5 minutes.

#### 5. Additions to Total Throughput Time

In order to simplify the AIDS III model, the time spent in the PCN and CSORT output hoppers was omitted. In addition, the throughput time for the work cell is understated as described in the previous section. After adjusting for batch size, the distribution of throughput times for the AIDS III simulations showed two distinct groups: (1) those transactions which did not go through image comparison functions (ICI and ICV) and (2) those which did. The average time spent in the PCN output hopper is 10 minutes. The average time spent in the CSORT output hopper is 5 minutes, and the average throughput time for the work cell is 25 minutes. The sum of these three times (40 minutes) was added to the throughput times for all transactions which did not encounter a microfilm processing delay. Nothing was added to those transactions which encountered a processing delay, since that delay is greater than the others.

#### D. COMPUTER SUBSYSTEMS

As the final hardware configuration has not been identified and specific equipment not selected, it was not possible to do a thorough static capability analysis of the computer subsystems. As an alternative, a review and analysis of the proposed computer subsystem data transfer requirements were made. It is recommended that a simplified model of the system data flow be developed in order to assist in determining the most effective hardware configuration for the functional requirements of AIDS III as presented.

In order to scope the size and complexity of the AIDS III System in terms of data flow, it was necessary to gather and summarize the message volumes and related record sizes that will be transferred between operational components and the computer subsystems.

The primary objective of this activity was not to develop a specific set of rates, but to analyze the size of the configuration and scope the complexity of the data transfer involved. Changes in volumes, card mix or inquiry identification rates could significantly change these data.

Although the computer subsystems are not yet in the design phase, it is felt that sufficient data were available to perform the analysis necessary to scope the operational feasibility of subsystems.

The data used for the analysis were primarily derived from References 1, 6 and 7, and is detailed in Appendix D. Specific operational component requirements are detailed in Appendix C. These requirements are discussed below and summarized in Table 6-5.

Table 6-5. Estimated Computer Subsystem Data Transfer Requirements

Computer Subsystem	Number of Messages/Hour	Number of Bytes/Hour
Data Entry and Display	23,324	1,529K
Image Comparison	7,277	185K
PCN and Image Capture	6,144	37K
Subject Search and Response Generation	21,594	783K
System Supervisor	61,221	2,055K
Technical Search	8,320	2,614K

The computer subsystem configuration proposed will, from a conceptual standpoint, support the AIDS III system. There are some concerns regarding the complexity of the configuration in network structure, message switching, and data transfer requirements. There also appears to be a proliferation of real-time computer system concepts and mainframe hardware.

#### 1. Data Entry and Display Subsystem

There is nothing inherent in the Data Entry and Display Subsystem (DEDS) to preclude its operability, but the timing requirements and input/output volumes are potential problems.

The Subsystem has the highest message transfer volume (23,324 messages per hour) of any subsystem except the System Supervisor. While the proposed configuration of DEDS is such that the processing is distributed over 14 Front End Processors (FEPs), it does complicate System Supervisor activities in selectively receiving and responding to the same FEPs. This can be accomplished but, in order to be effective, a proven and reliable network architecture and interface software is required. To meet the 30-second response time proposed (from the VDENT operator release of search parameters to the subject search response), the system will be demanding but within current technology.

The guideline to use Four Phase Equipment now in place could be a constraint in taking advantage of current technology. Functional requirements of DEDS should be carefully developed to ensure that the current configuration meets the needs of the system.

## 2. Subject Search and Response Generation Subsystem

The Subject Search and Response Generation Subsystem (SSRG) hardware appears to be well within current technology. Although correlating the information contained in the numerous data base files associated with the subsystem is complex, it is readily feasible with current data base management technology.

## 3. Image Comparison Subsystem

The Image Comparison Subsystem (ICS) handles microfiche location data. This is not dissimilar to existing computer-driven systems now commercially in use. From both a hardware and software viewpoint, there should be no difficulty in identifying the file to be selected and in directing the equipment to locate and retrieve it. Discussion of the station terminal is found separately in Section VIII.

## 4. Technical Search Subsystem

The Technical Search Subsystem (TSS) contains a number of specialized pieces of hardware (SARs, SPMs, AFRSs). A large volume of minutiae data is also handled internally in the subsystem. The operation of the Automatic Technical Search Pilot System (ATSPS) indicates that the concept is feasible (see Section IX). However, the system is expected to run at 100% CPU utilization (Reference 1, page 6-70), which is well above the 50% CPU utilization guidelines (Reference 1, page 6-65). The absence of sufficient capacity to clean up a backlog is a potential problem. In addition, the TSS consists of more than a purely technical (fingerprint) search. Extensive candidate filtering is employed prior to minutiae matching. Although there appears to be nothing inherent in the concept of this subsystem to preclude its operability, the amount of CPU used, even with the pre-matcher candidate selection algorithms, could produce a throughput problem.

As in other computer subsystems, the specific requirements of the function must be stated and utilized when selecting both hardware and software. The AIDS III system should not be bound to either the hardware or software used in the ATSPS. It must take advantage of the advanced hardware and software techniques available at the time of implementation and not held to the level of equipment used in testing a concept.

## 5. System Supervisor

The System Supervisor is the most critical aspect of the entire AIDS III System. If it is not reliable or does not function properly, the entire identification process will not meet its requirements or will fail completely. Yet, of all the subsystem concepts described in AIDS III, the System Supervisor is the least defined. This gives the impression that a bottom-up approach was taken in developing the AIDS III computer subsystems. This approach usually results in a system that does not perform in an optimal manner.

There are insufficient design data to state that the System Supervisor is not conceptually viable. It may, however, end up with more limited capabilities than stated, or be extremely costly in terms of computer overhead as well as software development and maintenance.

a. Data Transfer. The main function of the System Supervisor is that of data control and routing. Over 61,000 messages containing 2.0 million bytes of data are to be processed by this subsystem each hour. Many decisions based on the data source and system status will have to be made in handling this volume level. Protocols, retransmission of data, header information, equipment status, diagnostics, etc. are additional items that will act to substantially increase the System Supervisor work load. Various files under the control of the System Supervisor (MTR, equipment status, queue size, management report files) will be updated continuously and will require significant CPU time.

The overall baud rates of the lines between the subsystems and the System Supervisor appear to be sufficient but do not include the equipment status, diagnostics, etc.

b. Feedback and Control. AIDS III proposes that each subsystem, computer, and component will have a monitoring device connected in some fashion. These devices range from very simple (an empty hopper indicator) to very complex (switchover to a backup unit).

This segment of the AIDS III concept is not sufficiently developed at this time to allow a realistic evaluation. Whether the development and maintenance of the proposed feedback and control concepts will be cost-effective has not been shown.

c. Monitor and Control. The system simulation package and management report generation are also at an early stage of development and are only discussed conceptually. Both of these subfunctions of the System Supervisor appear to be large enough to occupy a significant portion of the System Supervisor CPU resources. They may be run in the backup machines so as not to interfere with the primary CPU. Based on JPL's experience in system simulation, sensor and system diagnostic data gathering, and information system development, these proposed functions are not small or uncomplicated efforts.

There is a need for monitoring to reflect card volume, card mix, service rate, available units, and other parameter changes. The level of complexity of the automated monitoring and control of work flow will be an object of analysis in the second phase of the JPL study.

It appears that the devices used to distribute cards to the cells (allocators) are a potential single point failure that would seriously disrupt the functioning of the system. The documentation does not adequately address the impact of failures in this equipment.



d. Computer Architecture. Although the proposed computer architecture is viewed as being loosely coupled in terms of stored data, there is a high degree of interdependency between the subsystems and the System Supervisor. A high volume of data is transferred between subsystems on an hourly basis (see Appendix C). Concern for data and system independence appears to be paramount in the configuration reflected in Reference 6, Figure 6-1.

Regardless of which subsystem is inoperative, the others can only process work in the queue. If the flow rate of cards through the system is close to the projected plan, all computer queues will be fairly small except for the PCN and Image Capture Subsystem (PICS).

If the system works as conceived, the configuration in Reference 6, Figure 6-1, may not be cost-effective. This approach shows backup front-end processors (FEP) and central processing units (CPUs) in a number of areas to minimize lost processing time in event of unit failure. This appears wasteful of CPU power, unless the second CPU normally handles part of the work load. Half of the processing capability should not be allowed to remain idle for any other purpose than to substitute in the event of a malfunction. If the total system is procured at the same time a commonality of CPU model and vendor can result, and a minimum of "spare" mainframes can be installed to back up the entire AIDS equipment complex. Even if some CPUs are forced into a larger model, the resulting flexibility could lead to substantial economies and improvements in performance.

A primary item missing in the system concept is a definitive set of design requirements for the computer subsystems. The AIDS III System, the hardware configuration development and the ultimate vendor selection would benefit if a set were developed. These requirements would address what has to be done in terms of function, data volumes and reliability rather than how it is to be done. The present level of architectural detail is too limiting to encourage a free and open response from industry. A good set of system design requirements related to data capture, processing, and response must also be developed. The development of functional requirements for the AIDS III System would permit uninhibited configurations and responses from industry.

Much more work is required on the System Supervisor. Its design, implementation and relationship to the other subsystems will be a critical point in determining the success or failure of AIDS III. Given that a computer (of some reasonable size) can handle the projected work loads, the major problem will not be hardware performance, but rather its cost and the cost to develop the associated software and networking. Until specific functional and design requirements are developed, the efficiency, effectiveness and costs of the subsystem cannot be realistically stated. The System Supervisor will be a complicated system to develop and maintain, requiring an extremely competent design approach.

In developing a configuration to support AIDS III, it may be very beneficial to build a model of the data flow. This would not only assist in developing of data transfer requirements but could also assist in the selection of a cost-effective hardware configuration.

e. Subsystem Interfaces and Protocol. The interdependency of the subsystems and System Supervisor, and the transfer requirements from the data source points, through one subsystem, to the System Supervisor, to another subsystem does not fully support the loosely coupled concept. The usefulness of the loosely coupled and distributed architecture is reduced in direct proportion to the interdependency of the subsystem for data gathered in other subsystems. Although physically separated, all of the subsystems are logically tied very tightly together. In the development of loosely coupled or distributed information/data processing systems, software and interface protocols sometimes are not given the attention required. Just as each of the machines must have hardware to connect to other machines, there also has to be software to support these interfaces.

Data handling varies significantly depending on its source format, use, etc. Software will be required to handle data routing decisions once transfer by the hardware is complete. As the number of machines and interfaces increases, so does the software necessary to handle the data. The more machines (especially front-end processors) involved in transferring data from one operational component to the subsystem that needs the data, the more these hardware and software handlers are involved. A large amount of system resources could be expended in just passing and checking this information from one computer to another. Since a large portion of the AIDS III system deals with transferring data from one computer system to another, this concept and its associated problems should be carefully evaluated. Any simplification and/or reduction in the number of computers needed in a particular path should be encouraged. So long as any portion of the network depends on the output of another, multicomputer systems become more vulnerable to malfunctioning as they become more complex.

All protocols, line interfaces, etc. that are used in AIDS III should be purchased, not developed in-house. Standard sets are readily available through suppliers. The ability to upgrade hardware and take advantage of new technologies is always desirable. Nonstandard interfacing can preclude cost-effective hardware and software upgrades. In-house development generally brings higher initial costs, maintenance costs, and time delays. Unless there is a demonstrated need to do otherwise, commercially available products should be used. There will generally be a reduction in system implementation lead time corresponding directly to the amount of off-the-shelf hardware/software that is purchased.

f. Diagnostics. The use of vendor-supplied diagnostics to facilitate hardware/software repair should not be overlooked. The expense of implementing these is clearly dependent on the machines and

system software utilized. Some of these, particularly CPU to CPU signaling, have proven quite difficult to implement in some of the systems used to process telemetry data from JPL flight projects.

The executing of on-line diagnostics seems to imply that the processing functions of the system need to shut down before running diagnostics. Periodic system checks should be designed so that potential faults can be identified without disturbing overall system function until necessary (such as replacing a failed piece of gear or reloading a computer). For nonstandard or special terminals, fault isolation methods should be an important element in their design. Some system of self-initiated diagnostic routines, standard checks and fault recovery is essential. Fully-automatic monitoring and corrective action can become complex and unreliable. Activities such as running diagnostics, isolating problems, and switching around failing units should probably remain under control of human operators. As proposed, the presence of on-site spare parts and experienced maintenance personnel are essential.

## SECTION VII

### AVAILABILITY

The availability (i.e., the probability that the equipment will be able to perform its function when required) of the operational components and related subsystems of AIDS III directly reflects the ability of the system to meet its requirements. In the Technical Memo, "Major Component MTBF/MTR Summary and Availability Design Goal" (Reference 24), Rockwell only discusses hardware and equipment Mean-Time-Between-Failures and Mean-Time-to-Repair of major deliverable assemblies purchased from various equipment manufacturers. Operational and software aspects of availability and related problems are not addressed.

The Mean-Time-Between-Failures (MTBF) and Mean-Time-to-Repair values acquired by Rockwell are from many different sources. Some data was obtained from documented references, while other sources were identified as being informal correspondence between Rockwell and the equipment manufacturers. Data collected by Rockwell over the past few years from other programs and predictions based on MIL-HDBK-217 were also used (Reference 24). It is not clear, however, which data are from which source. Data sources were provided only for the film viewers, the Automatic Fingerprint Reader System, and the Four Phase Data Entry equipment.

The maintenance data for each operational component as reflected in Appendix A, Operational Component Summary, do not include related computer subsystems (including the System Supervisor) or transportation system availability. The rationale for this is discussed below.

The component unit availability, ranging from 0.9737 to 0.9997, did not significantly affect the simulation model results for the overall system. However, when the effect of a single unit failure on the throughput capability of an operational component was computed, there were some significant areas of concern (discussed in detail in Section VI).

It has been JPL's experience that figures provided by equipment vendors tend to be quite optimistic, and records of operation rarely support their original optimism. Therefore, the numbers in the system concept should be viewed skeptically and considered on a "best case" basis until specific hardware has been identified and empirical data can be presented.

#### A. MAINTENANCE POLICY

The original maintenance data presented in Reference 24 did not reflect response time (i.e., time between failure identification and beginning of repair). Rockwell later estimated response time to be 1.0 hour in all cases. It was assumed that the hardware maintenance

personnel will be properly trained and on site (Reference 25). Rockwell's estimates were derived from failure data in Reference 24, and on predicted failure rates of equipment used in the AIDS II system. The number of failures expected for a 90% confidence level were then calculated.

The hardware maintenance staffing considerations are based on the establishment of a qualified maintenance force consisting of:

- (1) 2 stockroom clerks.
- (2) 2 electronic technicians - repair failed boards.
- (3) 8 electronic technicians - system level repair.
- (4) 3 electromechanical technicians - transport system repair.

This crew would maintain and repair highly sophisticated computer hardware systems, the conveyor belt transportation system and related elements.

#### B. OPERATIONAL COMPONENTS

To determine whether the system was able to handle the required throughput, single unit component availability based on Reference 24 data was computed for each operational component. This computed availability (detailed in Appendix A, Operational Component Summary) was introduced as a factor in determining the service rates in the dynamic simulation model.

The results of JPL studies of the availability of the Automatic Fingerprint Reader Systems (AFRS) and the process control number machines (PCN), while different from Rockwell's estimates, did not substantially affect the ability of the AIDS III System to perform the fingerprint identification process in a given period of time. In the case of the PCNs, Rockwell estimated 0.9906 availability while JPL's Study showed 0.9813. For the AFRSs, Rockwell estimated 0.9943 (excluding processors) while JPL's study revealed 0.9882 availability. Since the source was empirical, JPL data were used for the dynamic simulation model. The JPL studies are discussed in Appendix H, Study of AFRS and PCN Availability.

Introduction of an availability factor in both the static analysis and dynamic simulation model for operational components did not materially affect their ability to meet system throughput requirements.

#### C. COMPUTER SUBSYSTEMS

Computer subsystem availability could have a significant effect on the ability of the AIDS III to meet its performance requirements. While today's processors and data storage devices development have

greatly improved computer reliability, subsystem reliability will vary significantly between vendors. The hardware configuration will also affect system availability. The more networking, electromechanical operations and single point failures, the greater the chance of system failure. In selecting the final vendor and hardware configuration, reliability should be a major consideration. Beyond the period of equipment infant mortality, the reliability of the computer subsystem proposed should have minimal effect on the availability of operational components. Furthermore, Rockwell has proposed that each computer subsystem include a spare processor, available for immediate replacement in case of prime system failure.

A more thorough analysis of computer subsystem availability should be made when specific hardware is proposed. With present hardware reliability, there is no indication that availability rates will adversely affect the operational feasibility of AIDS III.

#### D. OPERATIONAL AND SOFTWARE FAILURE

In reviewing hardware availability, a lack of concern as to the impact of operational and software failures on the system must be noted. Based on JPL's experience with state of the art systems, availability of the overall system is more affected by operational and software failures than by hardware failure. These items are not sufficiently addressed in the AIDS III System Concept when discussing availability.

Additional failure and maintenance data related to software and technician failure are required for a realistic picture of system availability. Experience at JPL has shown that random software and operational failures do occur after the start-up phase of any data system, and are an important factor in the availability and reliability of a system of this size.

#### E. SENSITIVITY TO EQUIPMENT AVAILABILITY

The AIDS III design is sensitive to equipment availability in three cases if the component availability falls below 93% (see Table 7-1). This is a potential problem that can be solved by adding a processing margin where required.

Table 7-1. AIDS III Sensitivity to Equipment Availability

Work Station	Availability Used for Simulation	Estimated Minimum Availability*
PCN	0.9906	0.6102
MFILM	0.9996	0.8152
WAND	0.9986	0.6608
WORK CELL	1.0000	0.9356
AFRS	0.9882	0.8607
SAR	1.0000	0.7874
SEAR	0.9997	0.9136
ICI	0.9972	0.9425
ICV	0.9972	0.9058
AUTOCOR	1.0000	0.9541

\*At the indicated availability rates, utilization would reach 1.0.

## SECTION VIII

### COMPONENT OPERABILITY

The object of this portion of the evaluation was to determine at the component level if the AIDS III concept is operationally feasible in three major areas: 1) fingerprint card processing, 2) document processing and 3) computer subsystems. In the course of the evaluation, many questions arose concerning design details, specific operational functions and data handling. Because of the complexity of this system and the scope of evaluation in both level of detail and resources, only the conceptual questions that impact the overall system operability have been included in this report. Many detail design questions arose and are discussed in Volume II. An assumption was made that these would be addressed and resolved at the appropriate time in the design phase since feasible solutions are known to exist.

#### A. FINGERPRINT CARD PROCESSING

There is no evidence to suggest that the individual operational components described in the AIDS III concept will not work as proposed. The areas of concern are: 1) operational complexity, 2) the status of work station development and hardware integration of functions, and 3) the lack of conceptual data for some functions. These concerns are discussed in this Section.

##### 1. Automated Correspondence (AUTOCOR)

There is a lack of definition of the operations and functions that take place in this subsystem. The available information is sketchy and appears to assume that the functions now taking place in related activities in the current system will continue under AIDS III. How this transition is to be accomplished is not clear. AIDS III has work flow and computer system interfaces significantly different from the current operation. Additional development of the system concept for this function is needed.

##### 2. Automated Response Generation (AUTORESP)

This function is insufficiently detailed by the concept documentation. It is described at a more general level than most other functions. The process of response generation appears to be taken for granted. Discussion of the procedure and software to be used in support of this function is insufficient, and must be developed further.



3. Classification A, B and Classification Check (CLASS A, B and CLCK)

The AIDS III document (Reference 1, page 6-19) recommends a special terminal as the best data entry device for the classification (CLASS A and B) and classification check (CLCK) functions. The rationale for this decision is stated in Reference 1. It is not clear that a special terminal is a cost-effective design for these functions. AIDS III procedures still require that the classification be written on the fingerprint card. Consequently, the operator is required to perform two steps in the automated system, where only one is required by the manual system. Also, the operator is required to have two unrelated skills: fingerprint classification and data entry. As suggested by Rockwell in Reference 1, in-depth studies are strongly recommended prior to committing to this concept.

An alternate approach might be to mark the card at the classification work station, then enter all classification data at the data entry station. Eliminating a special terminal would save development expense, as well as the cost of the 224-plus terminals themselves. It would also reduce related computer subsystem hardware, storage and processing requirements.

The fingerprint classification and classification check functions proposed by AIDS III support three individual tasks: 1) fingerprint analysis and classification, 2) classification data entry, and 3) classification data entry verification. There are areas, however, that impact the productivity and cost effectiveness of the function and the ability of the classifier to perform the job well. These areas include closure, compatibility, error detecting, learning, job variety and economics.

As presently conceived, there are two alternatives proposed for handling the classification and classification data entry functions. The first is a one-position approach, where the classification technician classifies each fingerprint and keys a classification into a data entry terminal. The second is a two-position approach separating the classification task from the data entry/verification task (which exists for other data entry requirements as well).

The structure of the card flow in separating the classification functions into two separate modes in the system, and the location of the classification check function in relationship to data entry and verification, do not make the selection of either of these two alternatives as clear-cut as might first appear. It is recommended that additional design and testing be performed before commitment to a special classification terminal is made.

On the surface, the one-position approach seems to provide increased error detection by the data entry task. However, it may not be as cost-effective. It can also present an obstacle to learning the job. No special advantage or disadvantage is seen for closure, job variety or job skill. However, the mixing of two dissimilar skills can be detrimental to productivity.

The two-position approach may be more economical and easier in the training area. There seem to be some advantages when discussing skill levels and job variety. An apparent disadvantage of this approach is in error detection. This can be mitigated by the classification verification work station, which is expected to uncover data errors as well as classification errors.

Of specific concern in the area of job variety is whether or not the classification technician would welcome relief from the classifying activity when entering data or whether this would be seen as a burden. The capabilities for this position must be determined at the classification level and not at the data entry level. This also means that the technician would be required to learn to manipulate the terminal at a fairly rapid pace.

Fingerprint card flow through the system for classification data entry (CLASS A and CLASS B) and classification check (CLCK) should be reevaluated to determine the feasibility of the special classification terminal. Some consideration might be given to eliminating terminals at the CLASS A function (having terminals only at the CLASS B and CLCK functions).

If a decision to use a special classification terminal is made, several aspects of the proposed work station design are of concern. The recommended keyboard has some obvious problems. The physical layout is most appropriate for a hunt-and-peck operating style, and is not conducive to easy finger movement in a quick-response, touch-typing style. There is no backspace key for character corrections. The number sequencing is inverted, compared to the usual calculator or computer terminal keyboard. The "Enter" key is in an awkward position, and the "Clear Card" key is next to the "Card Complete" key. A small error in finger reach could cause an entire card entry to be lost. The same concern applies to the "Clear Entry" key, which is next to the "Add Reference" key.

A detailed discussion of these concerns can be found in Appendix E, Special Classification Terminal.

A third solution, which is beyond the scope of this report but which will be addressed in the final JPL report, is to automate classification by designing a system that does not require Henry classification at all.

#### 4. Centerline Sort (CSORT)

The proximity of this function to the Automatic Fingerprint Reader System (AFRS) function is a consideration, since it is proposed that the cards be carried to the AFRS via a conveyor belt, where they are stacked awaiting manual withdrawal by the AFRS operator. If, for safety or facility reasons, the AFRSs are located in a separate room or location, the conveyor belt mode of transportation may be restricted (see Section XII, Facilities).

5. Data Entry and Data Entry Verification-Cards (DENT-A and VDENT-A)

The primary concern as to operability of the data entry (DENT-A) and data entry verification (VDENT-A) functions is whether problems similar to those encountered in the development and implementation of AIDS II will apply to AIDS III.

Initial attempts to interact with the host computer in AIDS II were not successful due to insufficient file size and the throughput limitations of the host computer. The inability of the AIDS II system to hold unprocessed data beyond a preset length of time created a problem in its implementation. It is recognized that the original AIDS II host computer was old, unreliable and employed only because of budget constraints.

The AIDS III design is based on the functional requirements for AIDS II, and calls for a data entry/verify concept that is similar, but on a smaller scale (storing of search data only). Because of work backlogs resulting in file overflows, this methodology of saving the search data was abandoned. Search parameters are entered to make the subject search, but not verified. The same data is later reentered and verified when an identification has been made and the file will be updated. The inability of the data base file management system to respond to the overflow caused by the backlog in the existing AIDS II system, along with the slow response caused by an overloaded host computer, resulted in a decision to take additional data entry steps. A main concern of the evaluation team in the feasibility of the DENT-A and VDENT-A functions is not their specific operational capability, but rather the ability of the proposed system to handle file overloads and work backlogs of this nature. Data base file structures and hardware configurations must be flexible and expandable enough to meet these types of occurrences. (See Section X, for additional comments on data base management.)

In a system of the scale of the current AIDS II, the impact of redundant data entry is not significant, compared to not being able to process stored data. Under the expected AIDS III workload, duplicate data being entered into the system would have a serious effect on processing time and costs.

The ability of the Four Phase front end processors (FEP) to perform to the level proposed in the AIDS III Data Entry and Display Subsystem is also a concern. Currently, between 20-29 terminals are connected to each Four Phase FEP. AIDS III proposes that 31 terminals will interface with each CPU. Assuming that the search parameters and arrest data volume per message remain consistent with those currently used, improvements in the software or additional hardware will be required to meet the proposed system specifications.

Another concern in the operability of DENT-A and VDENT-A is the sequence of the data as it is entered from the card. Under some circumstances (multiple offenses), it is necessary to turn the card over a number of times for the data. It is recommended that further analysis of this potential problem be made and a redesign of the screen

format be considered. The screen format should reflect the needs of the data entry operator rather than emphasize ease of data handling for the computer.

#### 6. Film Processing (FLAB)

The effect of a backlog at the Film Processing function (FLAB), caused by simultaneous film delivery from the microfilm reader stations (MFLM), is of concern to Rockwell. This is addressed in Reference 1, pages 18 and 19. It is not clear how the figures on page 19 were derived or what steps will be taken to avoid this problem. While it is stated that the possibility of a backlog is reduced by having two processors in the lab, the effects of one being down or of an uneven work flow should be addressed in more detail. This could present a significant bottleneck in the system, as the microfiche processing is on the critical path in the identification process.

The handling of fingerprint cards requiring refilming due to processing problems is not addressed. This problem could develop into a complex control situation in locating and recycling the cards involved. The Master Transaction Record (MTR) will be the focal point for this control. Quality control requirements in the film processing laboratory were not fully addressed. The film processing activity must be constantly monitored with microscopes and densitometers.

#### 7. Image Comparison Identification and Verification (ICI and ICV)

The Image Comparison Identification and Verification (ICI and ICV) functions have the same possible operational problems. While these stations have not yet been developed and are of a conceptual nature, it is reasonable to assume that they can be developed. What is of concern, however, is the criticality of the need for clarity in reading fingerprints. The use of ultrafiche at 2000 images/fiche requires tremendous magnification when reading the image. Focus and ambient dust become significant operational problems. A visit to the Montrose, California, Directory Information Office of the Pacific Telephone Company demonstrated this problem. They are using MDS ultrafiche storage and retrieval systems (the same vendor and concept proposed for the FBI). In their system of 200 images/fiche, dust definitely presents a problem. AIDS III will have 2000 images/fiche. The JPL Photography Laboratory has a similar problem with microfiche and finds it necessary use electrostatic air cleaners. Before a full commitment to this approach is made, a prototype should be developed and thoroughly tested to prove the concept.

In addition, special lighting arrangements will be required to reduce eye fatigue. Current operations of a similar nature, with less and critical comparison and reading requirements, are equipped with controlled lighting. This may require the construction of a separate work area.

## 8. Semi-Automatic Reader (SAR)

The prototype seems fairly awkward to operate, and the cursor positioning seems time-consuming. Over the workday, eye fatigue may become a problem and a special room with controlled lighting will probably be necessary to alleviate eyestrain.

Using a trackball to position the cursor seems to limit the speed of this operation (and hence the accuracy). Special handling and use of the SARs could become a limiting factor in the success of an automated technical search for some cards. A very small increase in poor quality prints (e.g., 5 per hour) can easily overload the capability of the SARs. The basic assumption that only 3% of the cards from the AFRS will be rejects may be optimistic or at best highly variable (see Section VI).

Another approach would be to use a light pen and CRT capable of recording the X-Y coordinates designated by the operator. Each minutia is touched with the light pen and its X-Y coordinates are automatically recorded by the computer. The direction of the minutiae can also be entered with this efficient, human-engineered technique.

## 9. Search Review (SEAR)

The functions and decision processes required of the SEAR operator are rather complex. The function will require concentration, reliability, accuracy, and detailed knowledge of the entire system by the operator, in addition to a high eye/hand coordination in routing the card to one of seven future operations. In 15% of the cases, the SEAR operator must assign and verify an FBI number for new cards being added to the file.

It will require quick response for an operator to sustain a rate of 150 cards/hour. The review of data on two CRT screens with different formats, along with various hand operations (data entry, handling the PCN wand reader, and card sorting) gives the impression of a highly sophisticated operation requiring a great degree of concentration, ability and dexterity.

The handling of cards whose print images have not yet been processed through the image comparison functions (ICI and ICV) is not addressed. At SEAR, there is a real potential for card handling and storage problems.

The SEAR physical console is conceptual at this time, although Rockwell states that its design will utilize standard components. The implementation of such a console could be complex. A prototype of the dual screen SEAR console work station should be developed to thoroughly test the operational concepts proposed. In general, the SEAR function still is only a concept and requires significant additional development.

## 10. Wand Out of System (WAND)

The use of a hand wand reader in addition to keyboard data entry appears to be an awkward combination. A significant loss of efficiency and accuracy may be caused by combining card handling, keyboard entry and wand manipulation. A stationary optical character reader and associated keyboard may permit greater productivity and accuracy in this function.

## B. DOCUMENT PROCESSING

There are three major areas of concern regarding the AIDS III concept design for processing documents other than fingerprint cards. They are:

- (1) Omission of key functions.
- (2) Location of work stations not documented.
- (3) High number of documents returned to manual systems.

With 14,500\* documents a day to be processed, this portion of the AIDS III system requires much more attention than it has received thus far. These areas of concern are discussed below.

### 1. Omission of Key Functions

The documentation stops at the point at which miscellaneous documents and dispositions are used to initiate a subject search (Reference 7, page 6). No functional blocks are described for later processing, particularly where an identification or a file update would be performed. The handling of dispositions and some miscellaneous documents requires both an identification and file update step.

Final disposition reports (FDRs) are sent to the FBI Identification Division as a result of the action of a court. In many cases, the offense that an individual is convicted of and sentenced under by the court is not the offense he was arrested for. This makes it difficult for the FBI to match the offense on the FDR to the offense in their records. Compounding this problem is the tendency for the date on the FDR not to match the date reported on the arrest record.

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\*Reference 42, page 12, projects a daily processing volume of 22,000 in 1993. This is in conflict with ID Division Guidelines, Reference 23 page 3 and other Rockwell documents (i.e., Reference 7, page 6) which specify 14,500 documents per day. See Appendix I for other discrepancies.

Under the current AIDS II system, the FBI requests a "proof list" of offenses within a 30-day window of the date cited on the disposition to compensate for this situation. This proof list is printed out. In the case of an FDR with a contributor-quoted FBI number, one proof listing is printed. In cases where no FBI number is supplied, proof listings are printed for all candidates found as a result of a subject search. Both types of requests could be initiated from the data entry functions (DENT-B and VDENT-B). Up to this point, the AIDS III concept will accommodate this process.

Under the current AIDS II system, an identification process is run once the proof listings arrive at the appropriate work stations. The FBI must be sure that the person described in the FDR is the same person found in their file, with or without an FBI number. This identification process is analogous to the identification process used with fingerprint cards. However, in the case of FDRs, physical characteristics (e.g., color of hair, eyes, etc.) and other FBI acceptable data (e.g., date of birth, Social Security number, etc.) are used. Once the identification process has been completed, matching must be performed. In this procedure, the acquittal, conviction, and/or sentencing data on the FDR is matched with the arrest data on the AIDS II-generated proof list. After the offense and disposition data are matched, a file update transaction is coded, key entered and key verified. A similar series of steps is followed in response to correspondence requesting a correction to the FBI files.

None of the steps described above (identification, matching, file update-date entry or file update-verify) are covered in the AIDS III concept.

## 2. Location of Work Stations Not Documented

In the Rockwell documentation, a great deal of discussion is directed toward the work cell and alternative methods of optimally allocating facilities for the processing of fingerprint cards (References 1 and 8). Very little is said about the facilities for processing documents. For example, in Reference 1, a floor plan is shown ". . . which accommodates everything except the PCN machines and image capture machines . . . the latter items are assumed to be located near the mail room, which is assumed to be on another floor" (Reference 1, page 119). In Reference 8, page 28, the PCN machines are shown to be located with the card processing work clusters. It is not clear in either document if these include PCN devices used to process documents. It is doubtful that they are, yet it is not specifically documented one way or the other.

The same problems are found with the locations of other document processing units. While the quality control check, read, annotate (READ) and encoding (ENCDOC) functions are said to be grouped together into cells, their locations cannot be found on any floor plan. At the same time, the location of encode checking function (ENDOCK), which should be located with READ and ENCDOC, is not discussed.

### 3. Abnormal Number of Documents Returned to Manual System

According to the design, over 93% of the documents processed by AIDS III will be sent on to the manual system after the automated subject search. If we were to include the omitted functions discussed in paragraph 1, we would have to expect that the design would still direct the vast majority of documents into the manual system. This is in direct variance with the current AIDS II/manual system.

Since dispositions make up 67% of the daily arrivals of documents projected for AIDS III in 1993, they would make up the large majority of those going back into the manual system. Currently, the disposition notices are simply thrown away after being used as an update to an automated or manual record. We have no documentation to suggest that this policy is expected to change. Therefore, it remains unexplained as to why the bulk of these forms is to be sent into the manual system under AIDS III.

### C. COMPUTER SUBSYSTEMS

All of the subsystems have some degree of interdependency. If there is a failure or degradation of one subsystem, most of the other subsystems will be affected. Naturally, the further down-line the problem, the less the effects (other than the backing up of queues) are felt.

There are two conditions that have an immediate effect on a subsystem throughput. The first occurs when the System Supervisor is down or in a degraded mode. All functions in AIDS III will be degraded or cease functioning altogether.

The second condition occurs when a subsystem itself is in a degraded mode or down. This has the effect of drastically slowing or stopping all work in a subsystem except the totally manual operations (Blocking Out, QC Check, etc.). The queues will build in direct proportion to the amount of degradation involved. The degradation of a subsystem will also have an effect on the other subsystems directly related to it. This means that subsystems feeding data to the degraded subsystem would be affected, as well as those subsystems receiving data from the degraded subsystem.

#### 1. System Supervisor (SS)

The System Supervisor is the focal point of the entire information processing system associated with AIDS III. Since the System Supervisor is the message controller and router, none of the subsystems can communicate with any of the other subsystems if the System Supervisor fails. Under this condition, the entire AIDS III system is inoperative. There can be a limited amount of processing accomplished, i.e., the Four Phase equipment can continue to be used for data entry, with verification data written out to tape. However,



as no card routing can be accomplished, queues will build up at the data entry/verification functions. The System Supervisor has most of the aspects of a real-time system controller. It does not route the cards automatically, but through instructions to people, and does not optically read the PCN at most stations. Effects of a System Supervisor failure on management reports and the simulation model are recoverable, provided the data required is retained at the initiating subsystem until the System Supervisor is operational.

## 2. Process Control Number and Image Capture Subsystem (PICS)

The PIC subsystem is the initial controlling subsystem for AIDS III. The maximum rate at which cards can be processed through AIDS III corresponds directly to the rate at which the cards go through PICS. No processing can be started (other than opening and sorting the mail) until a process control number is assigned and both the Master Transaction Record (MTR) and Transaction Record (TR) are created. If the PIC subsystem is run in a degraded mode, the cards will not be available for down-line processing at the expected rate. If the subsystems down-line are degraded, the PIC subsystem can still be run at full capacity with an accompanying increase in down-line queues.

## 3. Data Entry and Display Subsystem (DEDS)

The fingerprint classification, wand-out, and data entry functions are all part of the DEDS subsystem. Any up-line degradation has the immediate effect of a reduction in card flow to these functions. Without the classifications and data entry (DENT or VDENT) functions, the cards cannot be processed by any of the down-line subsystems. A degradation in DEDS has a minor impact on the wand-out (WAND) function. All of the cards going through WAND are either being removed from the system to be routed for manual processing or returned to the contributor. The impact is felt in the delay in printing responses and in getting some of the wand-out cards to the manual system (approximately 70% return to the AIDS III system at a later date).

The impact at search review (SEAR) results in a delay in processing the response generation, rerouting of cards for a technical searches, re-searching, and final disposition routing. There will be an accumulation of data in the search statistics file, update files, and response files because there will be no authorizations for updates processed. This file size overload must be considered. DEDS is critical for the timely processing of cards through the classification and data entry functions, while at WAND it is only marginally critical. At SEAR, the impact is primarily in the release of cards from the system.

#### 4. Subject Search and Response Generation Subsystem (SSRG)

The SSRG subsystem is a critical entity of AIDS III. The subject search must be completed prior to routing the cards from the VDENT operation. Without knowing if a candidate was located, the card cannot be processed. The degradation of the SSRG has a serious effect on card flow and all interfaces with the TR file. Technical search and image comparison data cannot be processed when the SSRG is down.

#### 5. Technical Search Subsystem (TSS)

The TSS has less of an impact on the overall AIDS III system because it handles no data transfers except those directly relating to the technical search function, and processes fewer cards than the DEDS, PICS or SSRG subsystems. The degradation of this subsystem does, however, cause a backlog in the Automatic and Semi-Automatic Fingerprint Reader functions (AFRS and SAR). As the AFRS function has some ability to separately store its results until the TSS subsystem is operational, the backlog here can be minimized. Since this subsystem and some components are running at a CPU utilization of 100% (Ref. 1, p. 6-70), there is no excess capacity to work off the queue build-up without scheduling overtime. The other subsystem affected directly by a degradation in the TSS is the Image Comparison Subsystem (ICS). Fewer than normal image comparison requests will be generated until the TSS is fully operational. As the image comparison and verification functions (ICI and ICV) are running at near capacity, a surge from the TSS will require overtime in ICI and ICV (and probably SEAR) if the backlog is to be reduced.

#### 6. Image Comparison Subsystem (ICS)

A degradation of the Image Comparison Subsystem (ICS) will have the least effect on other subsystems and down-line functions. This subsystem does the final verification of a candidate match. The input is a result of either a subject or technical search resulting in the identification of one or more candidates. A degradation of the ICS will cause the queues at search review (SEAR) to build. There can be no rerouting of cards or response generation, etc. from SEAR until the ICS results are complete. All of the other subsystems can function more or less independently from the ICS, providing those interfacing with ICS can store the data to be processed until ICS is operational.

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SECTION IX  
SEARCH PERFORMANCE

A. AUTOMATED SUBJECT SEARCH

Automated subject search is a generic designation for the process of identifying and retrieving, in an on-line mode, a subject's record based on personal identification alone.

1. Evaluation

The performance of a subject search is evaluated in terms of its accuracy and reliability in making identifications or finding a candidate who will be positively identified. The FBI has required that the AIDS III Subject Search perform with a lower miss rate than the current manual name search (Reference 23). In order to make this evaluation, the current AIDS II Automated Name Search (ANS) was studied.

The ANS was designed for two reasons:

- (1) To evaluate the performance of an automated search based on name and descriptive information.
- (2) To use this evaluation as a basis for estimating the performance of the automated subject search for AIDS III.

The performance evaluation of subject search is based on AIDS II Volume Test results (Reference 44) which are summarized in Table 9-1. The results indicate that the subject search does perform better than the manual name search.

The second purpose of the ANS (providing a basis for estimating the performance of the AIDS III Subject Search) is impractical, since the current ANS system is too unstable to permit any final conclusions. Prior to June 16, 1980, the ANS unit was accepting only those searches that could be handled in a day. No queue was allowed to build up. After that date, all inquiries qualifying for a subject search were routed to the ANS unit. Full implementation of the automated subject search was hampered by the Identification Division's inability to hire qualified people, software reliability problems and the limited capacity of the hardware used. The capacity problem was partially resolved by an upgrade of the computer hardware. The software is still being modified. The problem of hiring qualified people is not easily solved, and it appears that it will be a continuing factor.

Given the similarities between the ANS and the AIDS III design, it appears that the accuracy and reliability of the subject search will be superior to the manual name search. Although there are decided differences between the two systems, there is nothing to prevent the subject search from being operationally feasible.

Table 9-1. Automated Subject Search vs Manual System Test Results

Type of Search	Date of Report	Searches	Poss. No. of Idents	Misses in Manual Found in Automated System		Misses in Automated Found in Manual System		Miss Rate %	Misses per Search
				No. of Misses	Miss Rate %	No. of Misses	Miss Rate %		
Criminal Name (Subject)	01/25/80	2356	1262*	120	9.51	0.051	28	2.22	0.012
Civil Name (Subject)	01/25/80	296	296*	26	8.78	0.088	5	1.69	0.017
*Based on tech search, there were 136 missed for criminal and 10 for civil by both manual and automated name search.									

## 2. Basis of Evaluation

In addition to the volume test results, the evaluation was based on a number of observations of the manual name search and the AIDS II Automated Name Search.

It has been observed that the manual system conducts searches for potential candidates in the following environment:

- (a) The master file is composed of 3 by 5 inch file cards containing the name and full fingerprint classification of each person represented in the criminal file, plus any aliases which have been used.
- (b) The searches are conducted entirely by hand, and are based upon the names appearing on the fingerprint card. The accuracy of each search is dependent upon the individual capabilities of the clerk making the search.
- (c) The update of the master file is manual as well, making the integrity of the master file dependent upon the timeliness and accuracy of the update.
- (d) The only index to the file is the name and sex appearing on the fingerprint card. If more than one file card has the same name, primary and secondary fingerprint classifications are used for greater discrimination.
- (e) A separate search must be conducted for each alias indicated on the fingerprint card.

The design of the AIDS III Automated Subject Search is similar to the original design of the AIDS II Automated Name Search and Automated Correspondence functions in several ways:

- (a) Data entry screen formats and identification record responses are substantially identical to those implemented in AIDS II.
- (b) All significant data elements being captured from the fingerprint cards and documents will continue to be captured in AIDS III.
- (c) The four existing query types (i.e., disposition, contributing agency, process control number, and miscellaneous) that are in use in AIDS II are sufficient for AIDS III.
- (d) Specifications for the AIDS III Subject Search are based on the functional requirements for ANS in AIDS II. It therefore appears that the search algorithms will be carried over to the AIDS III Subject Search.

There are several significant ways in which the AIDS III Subject Search will differ from the AIDS II Automated Name Search:

- (a) Even though the algorithms to be used in the search will be the same, the application programs will most likely be rewritten due to hardware and software differences.
- (b) File updating will be on-line in AIDS III, where it is batched in AIDS II.
- (c) The AIDS III design concept is assuming that the existing CPU loading problem can be resolved to efficiently service 32 terminals per Four Phase Controller. Currently, 31 CRTs and one printer are being serviced by one controller in the ANS unit. The other controllers serve 20 to 29 CRTs.
- (d) In 1993, the Subject Search master file will be 3.37 times as large as the current file (14.5 million compared to 4.3 million). A reorganization of the name index is planned to keep degradation of response time due to this growth to a minimum. Rockwell has estimated that the CPU time required for a search will increase by a ratio of 2.80 when the file has grown 3.37 times (Reference 21, page 11).
- (e) The file structures that will be utilized in AIDS III have not been determined. All indications are that a file reorganization will be necessary. The file structure will be dependent upon the hardware selected, the data base management system utilized and other operational considerations that are not yet clearly defined.

### 3. Description

The Subject Search and Response Generation (SSRG) Subsystem includes a search of the Computerized Criminal Name and Record File (CCNR), the updating of those files, the generation of user responses and related interfaces with the System Supervisor.

The CCNR is comprised of two separate but interrelated files. The Computerized Criminal Name File (CCN) contains one record for each FBI number, which includes personal descriptive data. The Computerized Criminal Record File (CCR) contains the arrest records, which is organized so that one record contains a separate date of arrest for a specific FBI number.

There are four indexes to the CCN file. The Name Index is a hierarchical structure permitting access to CCN records on a basis of combinations of sex, name, and either high (blocked-out) fingerprint classification or date of birth. For a 15-50 million subject CCN file, the index will require 275,000 fixed length records and 20-40 million variable index entries for certain common combinations of retrieval parameters (Reference 1, pages 5-2, 5-3).

The other three are unique identifier indexes: 1) FBI Number, 2) Social Security Number (SSN), and 3) Originating Agency Identification (ORI) Number and Originating Agency Case (OCA) Number. The number of records in each of these indexes depends upon the number of occurrences of the identifiers. For example, a 15-million subject file will have 15 million FBI number indexes, but less than 15 million SSN indexes. The ORI/OCA index records are purged from the index after one year.

The proposed system is based on each search being allowed a maximum response time of 30 seconds. Seven seconds is allocated to the System Supervisor to process the request and initiate the search. The search itself is allocated fifteen seconds and the remaining eight seconds are allocated to the System Supervisor for processing the response.

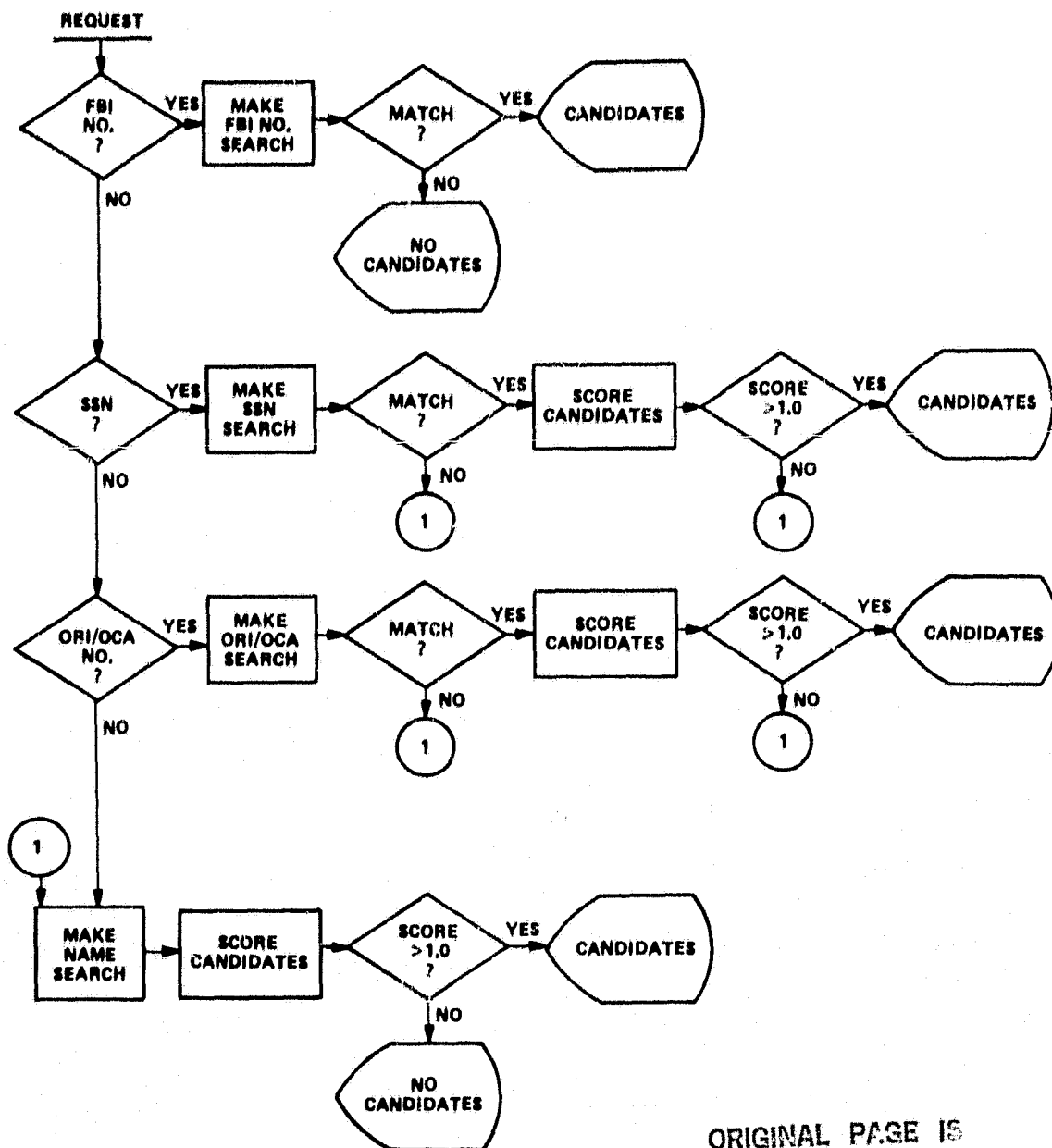
Figure 9-1 shows the logical flow of the Subject Search process. The subject search is initiated by the data entry verification operator (VDENT A or B) through the Data Entry and Display Subsystem (DEDS) and the System Supervisor. The VDENT operator enters the first screen of data (60-80 characters) which is the data required for the search (i.e., FBI Number, SSN, ORI/OCA, high-level fingerprint classification, date of birth, sex, race, place of birth and name). While the VDENT operator is entering the arrest data, the CCN file will be searched.

Searches can be initiated in one of the following ways: 1) FBI Number, 2) SSN, 3) ORI/OCA Number, or 4) name. The name search is the only one that is not based upon a unique identifier. A search by FBI Number has the highest priority, followed by the SSN, ORI/OCA Number and name search.

A name search will automatically be initiated if no candidate is found for a SSN or ORI/OCA Number. A routine name search must contain first name, last name, sex and date of birth. If the high level or blocked-out fingerprint classification is available, it will be used with the name and sex for the search.

Potential candidates are retrieved from the CCN file based on the exact matches of the search criteria. These candidates are then scored, based on the other available information such as name, high-level fingerprint classification, date and place of birth, sex and race. The scoring process results in a relative score for each FBI number retrieved. The SSRG subsystem selects candidates based on a minimum threshold score of 1.0. The individuals whose score exceeds 1.0 qualify as candidates.

Figure 9-2 shows the internal and external functional data interfaces of the Subject Search and Response Generation Subsystems. A control function within the SSRG allocates the requests to the appropriate subject search modules. The SSRG then notifies the System Supervisor of the search results, and a response is returned to the VDENT operator to route the fingerprint card for further processing.



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Figure 9-1. Subject Search



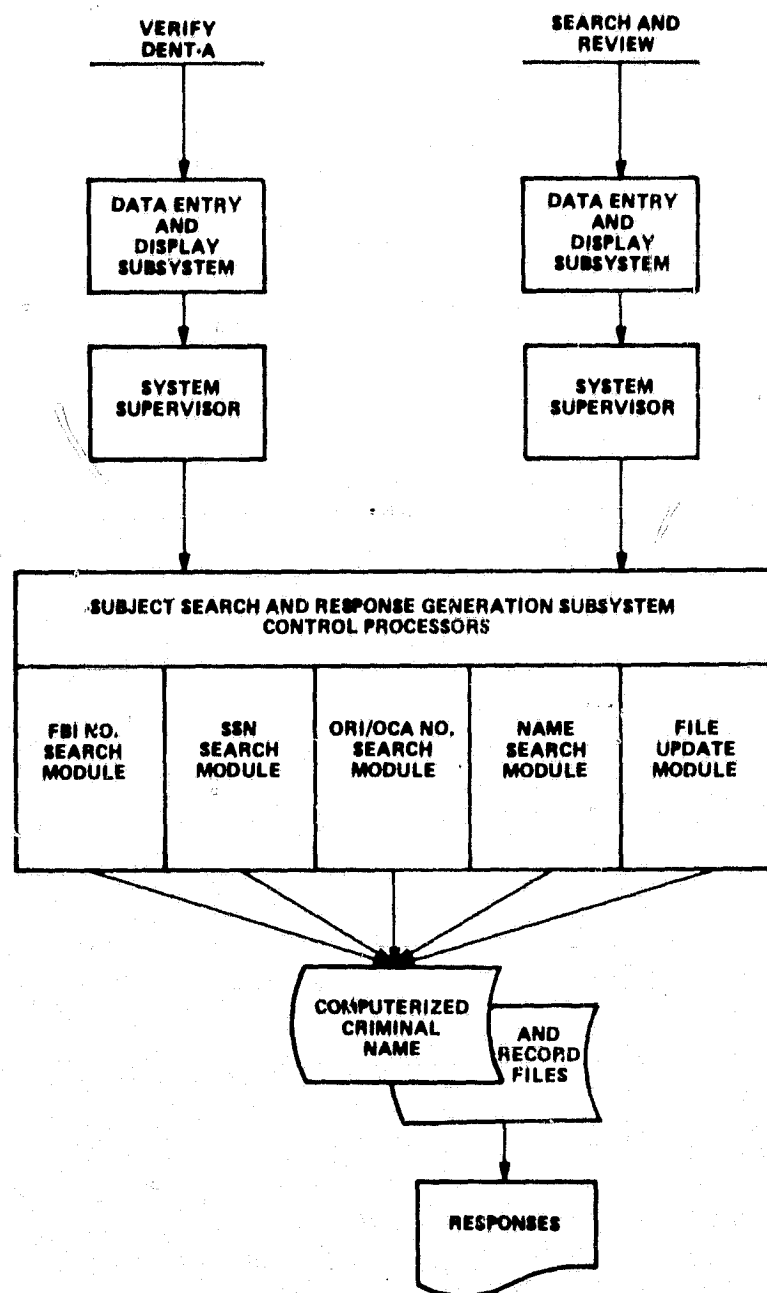


Figure 9-2. SSRG Functional Interfaces

All the verified data that was entered by the VIDENT operator is stored in a Transaction Record (TR) file until a case disposition is made. When the System Supervisor receives an authorization from search review (SEAR) the TR file data is retrieved, and the CCNR files are updated. The appropriate response is generated and sent to the contributor. If the case results in an identification of an individual already in the data base, search data is used to subsequently update the data stored in the file for that individual. If an identification was not made and a new FBI number is established for the individual, the associated data is stored permanently in the data base.

## B. AUTOMATED TECHNICAL SEARCH

### 1. Description

Technical search refers to identification searches based on fingerprints as opposed to searches based on name or physical description. The Automated Technical Search Pilot System (ATSPS) is a Rockwell-designed and developed system intended to:

- (1) Test the automatic technical search concepts.
- (2) Produce performance statistics on fingerprint searching and matching operations in order to measure search accuracy (sometimes referred to as reliability) and selectivity in an operating environment.
- (3) Provide a basis for estimating the costs associated with an automated technical search system.

The ATSPS has been evaluated relative to the manual system and as a stand-alone system. The only requirement placed upon AIDS III fingerprint search accuracy is that an automated search should perform better than a manual one (Reference 23). The test results indicated that the ATSPS does provide a lower miss rate than the manual fingerprint search.

Because of the limited size of the initial ATSPS data base, additional tests on other segments of the file have been useful in fully evaluating the technical search algorithms. Since the AIDS III fingerprint search is intended for use in on-line retrieval and file updating and the ATSPS is operating in a batch mode, the interactive search algorithms, on-line updating of files, and computer interfaces have yet to be specified. The procedures used by the AIDS III System may be different than those in the ATSPS, but it is expected that they will be equal to or better than those in the ATSPS.

Figure 9-3 shows the logical flow of the Automated Technical Search Pilot System and is described below.

The Minutiae Master File is logically divided into 22 categories or units of fingerprint classification. As of August 1, 1980, the ATSPS Master File was limited to one of the 22 fingerprint units of

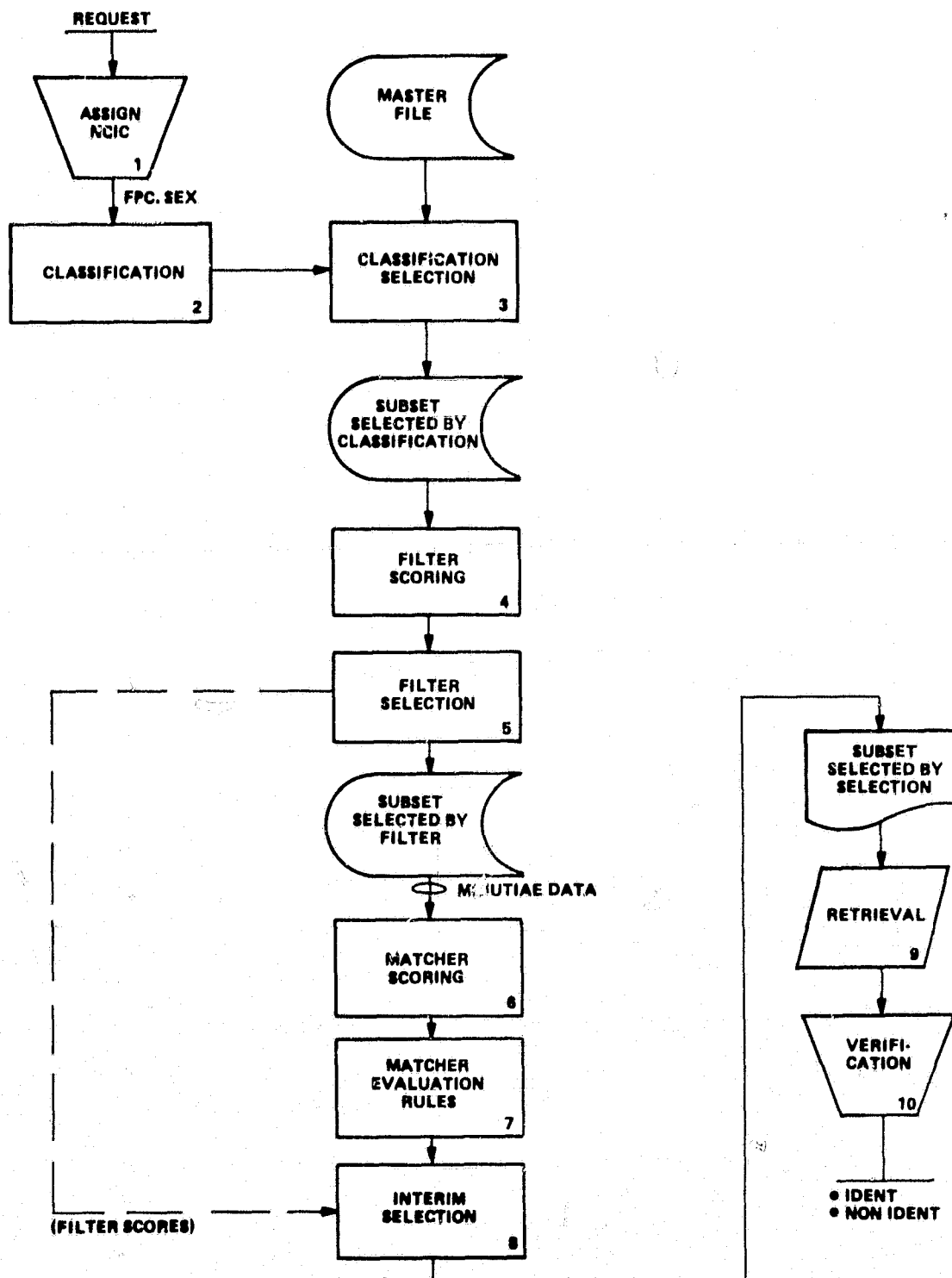


Figure 9-3. Automated Technical Search

the master file. The unit chosen (Unit 14) contains 560,415 male fingerprint cards, which are broken into 1972 segments or bins. The bin divisions were selected based on empirical analysis of the classification frequency distribution of 1.3 million cards. For comparison, the entire 22 units contain approximately 22 million master fingerprint card records.

A request for a fingerprint search enters the system, is classified by the National Crime Information Center (NCIC) fingerprint classification (process 1), and is entered into the system (process 2). The classification algorithms and search rules are applied to determine, as a function of NCIC-FPC and sex, the bins to be searched. Based on this classification, candidates are selected from the Minutiae Master File (process 3).

The purpose of the next scoring procedure, the Filter (process 4), is to eliminate obvious non-candidate records in the selected bins and to choose the best subset based upon similarities of fingerprint classification, sex, date of birth, race and height. In the fingerprint classification scoring portion, a score of minus 1 to plus 2 is assigned to each finger in the Master File subset. Each complete record (10 fingers) will then have a score between minus 10 and plus 20. Records with a score of 17 or higher are selected (process 5) to be evaluated further by the personal history and physical description data in the records. As result of this evaluation, a subset of records is sent to the Matcher scoring procedure (process 6).

In the Matcher scoring, the minutiae data of eight fingers (omitting the two little fingers) on the request record is compared with each record in the Minutiae Master File subset. A raw score is assigned for each finger comparison, and a raw score total is computed for all records in the subset. The Matcher Evaluation Rules (process 7) increase the accuracy and selectivity of the Matcher selection. These rules weight the raw scores based on finger position and pattern type. One rule selects passing fingers (those that have more than a minimum score), a second rule weights the scores and a third rule ranks the candidates based on this weighted score. The third rule also adjusts the candidates' final scores by increasing the score of the top-rated candidates and reducing the scores of all others.

In the ATSPS, the Interim Selection (process 8) evaluates each record in the subset data set based on the Filter and Matcher scores. If a candidate has high enough Filter and Matcher scores, the FBI number is listed and the candidate's fingerprint card is manually retrieved for positive identification (processes 9-10)

## 2. Test Implementation

ATSPS software testing began in May, 1979. To date, it consists of three phases:

- (1) Phase I (completed): Technical searches against known identification to determine reliability.

- (2) Phase II (in progress): Fingerprint card searches processed in parallel through Unit 14 of the manual system and the ATSPS.
- (3) Phase III (test/evaluation mode): New software is currently being tested and evaluated. Enhancements include limiting the size of the data set passing the Filter scoring, some Descriptor scoring (i.e., date of birth, race and height), NCIC-FPC scoring, an interim final selection process and update of the data base.

Fingerprint records for first-time offenders assigned FBI numbers since July 1, 1974, provide more information to the filtering algorithms (as shown below) because these records have been converted for name/subject search by AIDS II.

<u>Post July 1, 1974 Information</u>	<u>Pre July 1, 1974 Information</u>
Sex	Sex
NCIC fingerprint classification	NCIC fingerprint classification
Date of birth (year, month, and day)	Date of birth (year)
Race	Not available in the ATSPS data base
Height	
Minutiae	
	Minutiae

### 3. Test Results

- a. Phase I technical search (against known identifications) test results are shown below:

	<u>Number of Searches</u>	<u>Percentage</u>
Identifications	283	93.4
Misses	<u>20</u>	<u>6.6</u>
	303	100.0

The identification rate by data group:

Post July 1, 1974: 97.7%

Pre July 1, 1974: 90.1%

- b. Phase II technical searches (in parallel with manual Unit 14) and comparative statistics to May 24, 1980, are shown in Table 9-2.

Table 9-2. ATSPS vs Manual System Test Results

Date of Report	Searches	Misses in Manual System Found in ATSPS				Misses in ATSPS Found In Manual Systems		
		Possible Number of Identifi- cations	No. of Misses	% Miss Rate	Misses Per Search	No. of Misses	% Miss Rate	Misses Per Search
05-24-80	27,681	1,440	354	24.58	0.013	75	5.21	0.003

In addition to the tests run in Unit 14, three representative vertical slices of other areas of the data base were selected to make some additional tests. The purposes of these tests were to:

- (1) Make a preliminary determination of search reliability in portions of the file which provide extremes of classifications, or which provide special problems for the minutiae capture/usage process.
- (2) Determine and quantify the types of misses which occur in each area.
- (3) Make a preliminary determination of Automated Technical Search selectivity in each area. A radial loop-intensive segment (in Unit 3), an ulnar loop-intensive segment (in Unit 5), and a balanced area of female prints (in Unit 22) were chosen for these tests. The results of the tests are summarized in Table 9-3.

The results indicate that the search algorithm does maintain its reliability and selectivity when performing searches in areas outside Unit 14.

- c. Phase III was brought up on July 21, 1980 for testing (Phase II will continue until the new Phase III software is validated.) Because no final test results were available, the evaluation of the technical search algorithms is based upon the results of Phase II tests. However, preliminary results from Phase III testing indicate that the software is improving the performance of the ATSPS.

Table 9-3. Summary of the ATSPS Tests Outside Unit 14

	UNIT 3		UNIT 5		UNIT 22	
	Previously Identified	Not Previously Identified	Previously Identified	Not Previously Identified	Previously Identified	Not Previously Identified
NUMBER OF SEARCHES	70	108	128	93	105	107
FILE SIZE	78,405	78,405	114,230	114,230	106,773	106,733
IDENTIFICATIONS	67	-	119	3	102	1
RELIABILITY	96%	-	93%	-	97%	-
CONSOLIDATIONS	2	-	2	-	5	-
FALSE DROPS	1	15	8	18	4	17
FALSE DROPS/SEARCH	0.014	0.14	0.06	0.19	0.04	0.16

#### 4. Enhancements

The AIDS III Technical Search will incorporate enhancements that have been designed for Phase III of the ATSPS. Figure 9-4 shows the revised logic flow of the Phase III ATSPS. This is also the conceptual logic flow for the AIDS III Technical Search.

As in Phase II, the NCIC fingerprint classification is assigned to the request card (process 1) and entered to the system (process 2). The bins are selected (process 3), and filter scoring (process 4) and selection (process 5) take place. The number of records which may pass the Filter in a search is now limited to 250 (Reference 1, pages 5-46).

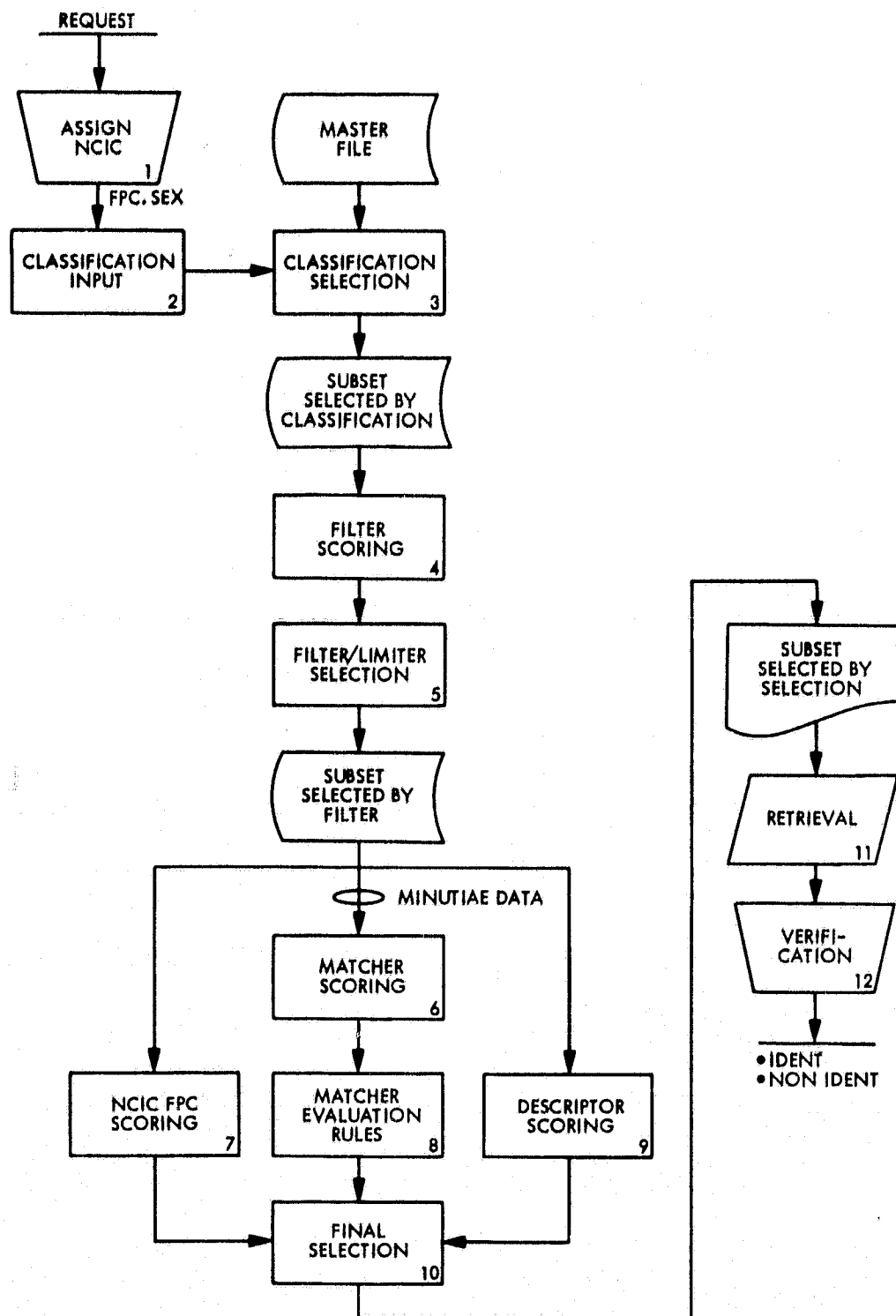
In Phase III, the NCIC-FPC (process 7) and some Descriptor scoring (process 9) are taking place in parallel with the Matcher scoring (processes 6, 8). The NCIC-FPC Scoring (process 7) will develop a score based upon the similarity of the search FPC (and references) to the FPC of each file candidate. NCIC-FPC Scoring involves the development of a distance measure based upon the degrees of disparity (or similarity) between the NCIC-FPC (and references) of the search print versus the file print. Individual finger classification distances are combined to produce a card level distance for each candidate. NCIC-FPC scores are then derived as a function of the card level distances, the rank ordering of the candidates, the distance differential between the file candidate being scored and the file candidate which has the smallest distance of all those in the search (Reference 35, page 12, Reference 36, page 16).

Fourteen descriptors will be incorporated into the Descriptor Scoring algorithm (process 9). These descriptors are included in the information normally recorded on a subject's fingerprint card and subsequent captures by the data system (Reference 1, pages 5-51). It appears that this data will be stored with the minutiae data for each subject. File update procedures for this data have not been addressed by Rockwell.

Rockwell has categorized the descriptors into three categories. Physical descriptors include sex, race, eye color, hair color, height, weight, scars, marks, tattoos and skin tone. Personal history descriptors include date of birth, place of birth, Social Security number and name. Criminal history descriptors include place of arrest and type of offense (Reference 1, pages 5-51 thru 5-53).

A Final Selection procedure (process 10) performs the final, automated determination as to which candidates (if any) will be selected for comparison with the inquiry search card (processes 11, 12). Identifications and non-identifications are handled as appropriate (Reference 1, page 5-84).





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Figure 9-4. AIDS III Technical Search

## SECTION X

### DATA BASE MANAGEMENT

The data base structure and management of that data are integral parts of any information system, especially one of the size and criticality of the one proposed in the AIDS III System Concept. The development and maintenance costs of supporting the information processes in AIDS III are significant. They are a major factor in developing and utilizing the data being accumulated for identifying individuals.

A make/buy evaluation of commercially available general-purpose Data Base Management Systems (DBMS) for use in the AIDS III System should be made. In the documentation received, there was no evidence of such an evaluation, nor that any data base management system technology assessment had been made. If evaluations have taken place, the results should be reexamined to determine the exact justification for rejecting the use of a commercially available DBMS. If such an assessment has not taken place, it should be completed prior to additional expenditures in the development of specialized software to support the FBI Identification Division function. This recommendation is based upon the following considerations:

- (1) AIDS III file structures are compatible with a general-purpose DBMS.
- (2) There are cost savings in implementation and maintenance.
  - a. automatic file access control and data security.
  - b. automatic audit trail and backup.
- (3) Upgrades have a minimum impact.
  - a. operating systems.
  - b. CPU.
  - c. disks.
  - d. data element revisions and additions.
- (4) DBMS parameters can be adjusted to meet specific needs.
- (5) Query languages are available.

The use of a commercially available DBMS does not imply that a single physical file or data base must be established. The rationale behind the recommendation is to establish the required number of physical data bases or files with common software support, and to increase the ease of handling logical interfaces.

Prior to the evaluation, a set of functional and data usage requirements must be developed for each logical file anticipated in the system. How the various commercially available DBMSs meet these requirements on a cost-effective basis will be a major consideration.

#### A. GENERAL COMMENTS ON GENERAL-PURPOSE DATA BASE MANAGEMENT SYSTEMS

While the cost per bit of storage and execution cost per instruction have both been decreasing, the same trend has not been true of software development. Since software development has continued to be a people-oriented activity, a higher percentage of the total system cost in acquiring and developing a computing system is accruing to software development (Reference 28).

General-Purpose Data Base Management Systems are characterized as software packages which provide a flexible facility for accommodating different types of data files and operations while requiring less programming effort than conventional programming languages. A DBMS provides a software environment which is not tied to a particular set of application programs or files. This provides tremendous flexibility in utilizing program maintenance personnel.

In selecting or developing a software capability for data processing functions, there are two extreme alternatives: 1) Design and implement the system by tailoring it to a specific application, without using any prepackaged software or 2) utilize a commercially available DBMS, and build any necessary additional functions with application programs (Reference 22).

The first way necessitates a large initial investment in data base system design and implementation. Although a great deal of this effort has already been invested in AIDS II, over \$5.9 million remains to be invested in computer subsystem software development. In the development of a homegrown data base management system there is generally a substantial time lag between system conception and implementation, especially if the hardware and operating systems are not known.

The reliability and dependability of commercially available DBMSs is continually increasing. Experience at JPL in the development of homegrown data base management systems vs commercially available systems has shown that: 1) implementation times for commercial systems are shorter, 2) reliability of commercial systems has been equal or higher, and 3) costs have been less than if the systems had been developed in-house.

#### B. FILE STRUCTURES

It does not appear that the structures of the files proposed for AIDS III (Reference 14) are of a nature to preclude the use of a DBMS. File maintenance and data updating is always complex. Reutilization of freed storage space in the data base is automatically managed by most DBMSs and is transparent to the user. Special utility programs to do this will not be required. Establishing functional requirements for the AIDS III data bases will greatly assist in the development of hardware requirements.

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### C. COSTS

An important fact to remember when designing a computer-based system is that hardware is cheaper than software development, maintenance or operation costs. If the present trend continues, this differential will be greater and greater (Reference 28).

The proposed AIDS III system appears to treat the problem of data base management as a software coding exercise. Large amounts of specialized assembly language and COBOL software are proposed which would be sensitive to environment and data changes, and would tend to maximize both new development and long-term maintenance costs.

The basic problem to be solved by the AIDS III system is that of managing an inquiry into a large collection of highly sensitive data. The system proposed is a highly complex simulation of the manual system containing electromechanical devices, electronic hardware and human interfaces. If it is to support the FBI Identification Division in a cost-effective manner into the mid-1990's, it must be able to respond to change, both technical and societal. As time passes, equipment will be changed due to age and advances in technology. Future social pressures may cause changes in the data and in its use. Hence, the data base must remain adaptable and the system flexible.

Programming costs are an important factor in implementing AIDS III. One means of determining program development time and costs involves the average number of lines-of-code (LOC) produced per hour. There are various standard rates that can be applied, but three sources: Johnson (Reference 29), Brooks (Reference 30) and Walston (Reference 28) are fairly consistent in stating LOC productivity rates. Batch systems are in the 6000-7000 LOC/man-year range, compilers, 2000-3000 LOC/man-year, and operating systems 600-800 LOC/man-year. Recognizing that a data base management system is more complex than a batch system, but not as involved as a compiler or an operating system, an extrapolated LOC productivity rate could be in the 4000-5000 LOC/man-year range. Rockwell has stated that the coding will probably be in assembly language which, being a lower level language than COBOL, could have a different productivity rate. Using 5,000 LOC/man-year as an assumed rate and 500,000 lines of code estimated for the task (Reference 15), this equates to about a 100 man-year effort. If only one-quarter of the estimated 500,000 LOC are to be devoted to the data base management system and related inquiry, backup and operational procedures, 25 man-years will be applied to development of the data base management system. Given the estimated cost of \$76,000 per man-year of programming effort (Reference 34), the development cost becomes \$1.9 million.

High-level software maintenance people will be required to maintain the various data base files. The more varied the file structures in a system, the wider the range of software maintenance skills and knowledge required.

The security of the information being utilized in AIDS III is critical. Protection not only from unauthorized inquiries or data manipulation, but also in the form of audit trails, backup, restoral facilities and system integrity. Security is a major concern with computer systems and is not sufficiently addressed in AIDS III. Today's commercially available general-purpose Data Base Management Systems provide this as a standard feature.

Data protection and security involve insulating a data base from system failures, vandalism, natural catastrophes and the like. This includes backing up multiple files containing tens of gigabytes ( $10^9$  bytes) of data and restoring them in a timely manner. DBMSs provide a natural facility in this area.

#### D. CONFIGURATION UPGRADES AND DATA ELEMENT REVISIONS

When a system is developed for a specific application utilizing a specific hardware configuration, it may not be flexible and responsive to internal and external environmental changes. Upgrading central processing units (CPU) or storage hardware, or using an improved version of an operating system to take advantage of the continuing improvements in the state of the art can have significantly less effect on a commercially available DBMS than on a homegrown system in terms of both effort and costs expended.

Modifications or changes of data elements in the system will require reprogramming and possible file restructuring. All data now in the system may not be needed or required in 1990. If a commercial DBMS is structured to permit elimination or separate handling of that data, additional storage space can be freed and used for new file records.

DBMS technology uses separate logical and physical data base descriptions to completely insulate user applications from changes to the data organization and hardware environment. In the AIDS III System Concept (Reference 14), it states that assembly language DSECT macros and COBOL record descriptions will be used to provide data independence. This means that, whenever a record element is changed these descriptions must be changed, and all programs referencing these data must be recompiled, retested, and recertified. If, for example, a change from a 3 to a 2 byte minitiae file format is desirable, this could require significant effort in making modifications to existing programs. DBMS technology requires modifications only to affected schemas/subschemas (data descriptions) and furthermore insulates users from hardware upgrades, data reorganization, and all but major record restructuring.

#### E. ADJUSTMENTS TO MEET SPECIFIC USER NEEDS

Some DBMSs are structured to facilitate whatever specific modifications may be necessary for unique search processing. In information systems utilizing computers it is important to identify any areas in the system where data flow is inefficient or ineffective, and those areas where a slight improvement or modification in either the software or hardware structure will produce a significant throughput improvement. Generally speaking, commercially available DBMSs provide statistical information and control information that can be used to improve processing of throughput time. In addition, the acquisition of a data dictionary, query language, report writer, etc., could greatly extend and enhance the capabilities of the AIDS III system while providing useful management information upon request without extensive programming.

The structure of the data bases for various logical and physical files must be such that they can handle greater than expected capacities through the addition of hardware, rather than needing reprogramming. Reference 14 (page 5) states "the tremendous volumes of records to be processed by this system dictate that the files be designed in a manner which will optimize processing efficiency." While this statement has validity when addressing processing throughput, it does not address the software management complexity introduced by the development of a homegrown system. It precludes or presumes that commercially available DBMSs will be inherently slower and adversely impact the ability of the overall AIDS III system to process the inquiry in an acceptable period of time. In reality, DBMSs can be tuned to meet the specific requirements of the user.

It is possible that a commercial DBMS package may require slightly greater computer resources than a homegrown, tailored system. The acquisition cost of more powerful hardware should be considered as part of the evaluation. This additional cost can be offset by savings in software and by improved implementation schedules. In addition, the configuration of the system may be such that any additional resources required are already available.

#### F. QUERY LANGUAGE

In the AIDS III concept, a number of inquiry requirements are identified and data files established to provide management information. These queries will require computer programs to interface with the files involved. There are also a number of files that interact with each other and demonstrate a high complexity for those inquiries known today. Inquiries handled in the future may be best served by the use of the query language available as part of a selected DBMS. In addition to management and statistical information, a flexible query capability could enhance the performance of the on-line query (QUERY) function.

Reference 14, page 5 states that there are ". . . no plans to incorporate a generalized query capability to the AIDS III system. AIDS III is a highly specialized system which is necessarily dedicated to the processing of fingerprint cards and related documents. Other uses of the system are entirely secondary to this primary purpose." While a general-purpose query capability is not planned, "additional specialized query capabilities will be incorporated...should the need arise" (Reference 14). To promote standardization and facilitate expansion, it appears that a query language with syntax tailored to AIDS III is already planned. Based on JPL's experience in information systems, the probability of query capabilities being needed is high. As sophistication and a better understanding of the capabilities of AIDS III are developed, there will be an increased inquiry demand.

#### G. CONCLUSION

For the above reasons, it is recommended that a make/buy evaluation of the use of a commercially available general-purpose Data Base Management System be made and incorporated in the implementation of AIDS III. The implementation of a data base management system prototype could greatly assist in this evaluation, and would be useful in determining the full benefits of commercially available general-purpose Data Base Management System.

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## SECTION XI

### FILE CONVERSIONS

Implementing AIDS III will require restructuring and reformatting the Minutiae Master File (MMF) and Computerized Criminal Name and Record (CCNR) files. The same basic procedures (including testing) used in establishing the Automated Technical Search Pilot System (ATSPS) will be employed for the AIDS III conversion. Data file structures and format requirements will vary depending on the hardware and data base technology used. A brief general discussion of Rockwell's file conversion concepts can be found in Reference 16. Conversion of source data and data files is addressed in Reference 12.

Conversion of the fingerprint card master file to microfiche is mentioned in Reference 2. It was estimated that the conversion will take 15.5 months to convert. The fingerprint card/microfiche conversion plan briefly discusses costs, time and resources but does not discuss how the conversion is to be done.

The complexity, scope and coordination required for a project of this size cannot be overemphasized. A comprehensive validation test and transition plan is planned for AIDS III, although it has not yet been developed. Details (both technical and management) for the creation of AIDS III data and microfiche files require further consideration and development.

#### A. MINUTIAE MASTER FILE AND COMPUTERIZED CRIMINAL NAME AND RECORD FILES

As of July 16, 1980, the Technical File Conversion Unit of the Automation and Research Section had converted 12,701,591 fingerprint master cards into machine-readable format for minutiae data. This is out of a planned conversion of 14,500,000 cards. There is no expected additional card conversion necessary when implementing AIDS III. Depending upon the hardware selected and the software utilized in establishing and maintaining the minutiae files, a conversion from the current format, file structure and equipment will be necessary. Data from the technical master file conversion is being archived and maintained on magnetic tape.

The information contained in the Computerized Criminal Name and Record (CCNR) file is being accumulated and maintained by the AIDS II system on an ongoing basis. Rockwell anticipates that the CCNR organization and file structure will be different in AIDS III than in AIDS II, making a CCNR file conversion necessary (Reference 14, page 7). The CCNR data will be extracted from data and files in existence at the time of AIDS III implementation. The CCNR data will be extracted directly from the Technical Master File's archived tapes and existing CCNR files. At the time of the AIDS III operational start-up, the data bases will be current and will contain records that have



been subjected to extensive editing. Programs to extract data from the AIDS II CCNR files and the Minutiae Master File (MMF) created during the Technical File conversion do exist and have been utilized extensively by the Automatic Technical Search Pilot System (ATSPS). The value of these programs however, depends upon the hardware and data base management technology ultimately selected. A detailed plan for the management, development, test and integration is required before a transfer from the AIDS II operational and AIDS III test modes to the proposed AIDS III System can be expected.

Data entry screen and identification record response formats are expected to be substantially identical to those implemented in AIDS II (Reference 14). Data screen file formats do not appear to require a conversion but, depending on the final hardware and data retrieval system selected, response data in the CCNR files may require a reorganization.

A data base update method has not been formulated for the AIDS III design. In Reference 14, it is stated that it "should be assumed that updating will be performed on-line." Transactions will be accumulated on a serial file device. In the event of a system malfunction, the file can then be rebuilt by a combination of restoration and reapplication of the interrupted transaction. Extensive development work is still required in this area. The implementation of a reliable and effective on-line data base update methodology is critical to the success of AIDS III (See Section X, Data Base Management).

The standards for software development will be based on the FBI Technical Services Division Systems Development Standards manual that Rockwell understands is now in preparation. A review of these standards was not included in the evaluation.

MMF and CCNR file conversions should not be considered as simply extensions of the ATSPS conversion with some fine tuning added. The size and complexity of AIDS III is far greater than ATSPS. It is implied that the programs used in the ATSPS (where applicable) will be used in the AIDS III conversion. It may be more effective to utilize the system concepts but rewrite the programs, in view of today's technologies. Whatever route is taken, the MMF and CCNR file conversions will require a level of design testing and implementation management which is not detailed in the implementation plan at this time.

It is implied that the FBI Technical Service Division will be responsible for the development of the design requirements (Reference 14, page 17). The line of responsibility between the concept or functional requirements of the system and the system design requirements is not clear. Additional conceptual and design effort is needed before reliable time and cost estimates for data file conversions can be established.

## B. MICROFICHE FILE

The only reference to fingerprint card conversion to microfiche images was found in Reference 2, page 164. Costs, resources and schedules were generally addressed. It is stated that, working 15 hours a day, it will take 15.5 months to convert the estimated 14 million fingerprint cards (from mid-1980 to late-1981). No discussion of how this will impact the ongoing system or the computer subsystem interface requirements is noted. More detail is required in this area. Converting fingerprint cards to readable microfiche images is a critical activity and will require an extensive effort.

## SECTION XII

### FACILITIES

Development of the facility requirements for the AIDS III System will require additional work before a realistic evaluation of requirements can be made. AIDS III concept changes are not yet fully reflected. It is recommended that a further review of safety and fire protection requirements be made.

#### A. EQUIPMENT LOCATION

In the AIDS III System Concept (Reference 1), it is not clear whether Figure 6.6-6 is an update of Figure 6.6-1 or is complementary to it. Much of the computer hardware shown in Figure 6.6-1 is not reflected in Figure 6.6-6, while the process control number machines and the microfilm image capture equipment are shown in Figure 6.6-6.

The revised plan (Reference 8, Figure 8-4) indicates a larger floor area and does not specifically address the proposed computer central processing units (CPU) or front end processors (FEPs). The floor space requirements presented in Reference 1, Table 6.6-1 must be updated to reflect the space requirements for the work cell, the transportation mechanisms, and the number of work stations required. In addition, safety requirements may require additional considerations. Consideration of interfloor modes of transportation as well as between-station conveyor systems need further examination.

#### B. CARPETED FLOOR

Placement of carpeting on a computer room floor is not recommended. Based on the experience JPL has had in its numerous computer areas, there is a tendency for dust and dirt to gather underneath the equipment and, in general, carpeting does not promote the cleanliness required for a computer room environment as well as tile flooring does. Carpeting in normal office work areas, including those having terminals, is recommended.

#### C. SAFETY CONSIDERATIONS

The floor layout presented in Reference 1, Figure 6.6-1, with all computers grouped in the center of the building, may generate a safety hazard. Discussions of permanent walls and partitions, air-conditioning ducts, various subfloor cables and glass walls around the computer room do not reflect the application or consideration of RP-1, Standard Practice for the Fire Protection of Essential Electronic Equipment Operations, issued August 1978, by the U.S. Department of Commerce, National Fire Prevention and Control Administration (Reference 43).

Using the same ducts to run air conditioning from the computer area to the employee area raises the possibility of smoke being transmitted through the building or work areas via these ducts in the event of a fire. Provisions could be provided to expel smoke directly to the outside of the building in the event of a fire. RP-1 should be reviewed for further consideration in this area. In addition, if water is used as part of the air-conditioning system, appropriate water detection devices should be placed in the raised floor area to detect possible water leakage.

Installation of any power transformers or Uninterrupted Power Supply (UPS) batteries on the same floor or within close proximity to the work area could also present a hazard from fire and resulting smoke. It is not recommended that power transformers or associated power generating equipment of this nature be located near either the computer room or the general working area.

#### D. FIRE CONTROL

The discussion of fire prevention in Reference 1, Paragraph 6.6.7 should also be reviewed in light of RP-1. Using a Halon fire extinguishing system within the control room should be reconsidered. Halon is not a recommended method for controlling fires within a NASA computer room. This is due to the toxic nature of Halon, and the time delay required for the evacuation of persons in the fire area (Reference 40). In addition to CO<sub>2</sub> extinguishers mounted on the walls for electrical fires, H<sub>2</sub>O extinguishers should be available in the event of paper fires (especially those in wastepaper baskets).

The use of a "wet" sprinkler system may be an alternative. Problems in such a system are caused by contaminants in the water, rather than the water itself, which can be controlled by regular flushing of the water system.

In order to ensure the best available fire protection, fire-stops should be in the walls between the computer CPU area and the employee working area. This includes the ducts through which all interconnecting cables pass, including cables between computers and their assigned peripherals. Cabling for terminals outside the computer room should also pass through fire-stop control walls. There should not be glass walls between the computer area and the employee working area.

#### E. POWER SUPPLY

Using the UPS as a methodology to shut down the computer system until facility power is restored appears to be reasonable. Some questions arise, however, regarding the exact power configuration that would ultimately be required, which will depend upon the exact equipment being used. UPS should not be utilized beyond graceful system shut-down. Since lights, air-conditioning and power for individual

terminals would not be available, it does not seem practical to keep the computer running if it can be gracefully shut down. It is recommended that procedures to handle the controlled shutdown and start-up of the system and be developed and thoroughly tested to ensure that no data is lost in the input or inquiry front-end processors. Since power cables and the like are located under the floor, smoke detectors should be installed at the same level.

#### F. OTHER

As previously mentioned in the report, consideration must be given to the need for controlled lighting at the image comparison and verification function (ICI and ICV) and the Semi-Automatic Readers (SAR). Activities associated with image capture on microfilm (MFILM) and microfilm processing (FLAB) should be in a separately enclosed room, properly ventilated, with appropriate fire protection.

## AIDS III OPERATIONAL FEASIBILITY

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## APPENDIX A

### OPERATIONAL COMPONENT SUMMARY

Table A-1 contains a summary of the basic data gathered for each operational component in the AIDS III System Concept. The data contained for each component includes:

#### Acronym:

An abbreviation used in the system to identify the operational component. Table A-1 is in acronym order.

#### Description:

Complete description of each component can be found in Appendix G.

#### Service Rate:

The processing rate of a single unit in the component.

#### Service Distribution:

Constant or exponential service distribution rate within the component.

#### Number of Units:

The number of units proposed in the AIDS III System concept. If a component has units in the work cell, the number of units in each work cell is also shown.

#### Interfaces:

**Input:** The source of the data entering the component on an hourly basis. This is broken down by percentage and volume based on workload guidelines. Interfaces with computer subsystems reflect hourly messages and bytes/message transfer rates.

**Output:** The destination of the data leaving the component on an hourly basis. This is broken down by percentage and volume based on workload guidelines. Interfaces with computer subsystems reflect hourly message and bytes/message transfer rates.

#### MTBF:

(Mean Time Between Failures) The average value of time intervals between successive failures of equipment over the total operating time.

MTTR:

(Mean Time To Restore) The time from determination of equipment failure to locating the failure and repairing it.

% Availability:

The probability that the equipment will be able to perform its intended function.

Table A-1. Operational Component Summary

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- ABILITY <sup>f</sup>
				TOTAL	PER WORK CELL					
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>			INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
AFRS	Automatic Fingerprint Reader System	250 <sup>g</sup>	C	5	NA	CSORT-100% (1033)	Total-1033 SAR-3Z SEAR-97% (1003) TSS • 1033 messages • 2000 bytes/message System Supervisor • 1033 messages • 10 bytes/message	700.0 <sup>h</sup> 106.9 <sup>i</sup>	4.0 <sup>h</sup> 2.0 <sup>i</sup>	99.43 98.82
AUTOCOR	Automated Correspondence	100 Pieces	E	25	NA	Total-2410 pieces • F/P cards • SEAR(25)-19% (468) • CLCK(19)-12% (282) • WAND(8) -3% (83) • Documents • VINDEX-B(34)-2% (60) • AUTORESP(26) • IDENTIS-35% (837) • N/IDENTIS-28% (680)	MAIL ROOM(1)-2410 pieces	-	-	-
AUTORESP	Automated Response Generation	2000 (Output Documents)	C	26	NA	System Supervisor • 1517 messages • 40 bytes/message SSRG • 1512 messages • Unk bytes/message	AUTOCOR-Total 1517 (Output Documents) • IDENTIS-55% (837) • N/IDENTIS-45% (680) Manual-294 Index Cards (plus unknown # of new alias)	400	2.0	99.50
BLO	Block Out	50	E	30	2	ENCK-100% (720)	DENT-A-100% (720)	-	-	-
CLASS-A	Classification-A	10	E	120	8	ENCK-100% (1137)	DENT-A-100% (1137) DEDS (Legible) • 1137 messages • 80 bytes/message (avg) System Supervisor • 1137 messages • 10 bytes/message	7000	2.0	99.97

<sup>a</sup>Unless otherwise noted the data reflects cards at a per hour rate

<sup>b</sup>C = Constant Rate  
E = Exponential Rate

<sup>c</sup>Values and Z splits may not agree due to Z rounding

<sup>d</sup>Mean-Time-Between-Failure (excludes computer subsystem components)

<sup>e</sup>Mean-Time-to-Restore (Includes Response Time)

<sup>f</sup>1) Does Not Include Subsystem or Transportation Availability Data  
2)  $\frac{MTBF}{MTBF + MTTR}$

<sup>g</sup>JPL Study Data (Current Service Rate - 165 cards/hr. plus Rockwell proposed AFRS modifications).

<sup>h</sup>Rockwell Data

<sup>i</sup>JPL Study Data

<sup>j</sup>70% of cards leaving the function for the Manual System reenter the Automated System.

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Table A-1. Operational Component Summary (Continued)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- ABILITY <sup>f</sup>
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
CLASS B	Classification-B	10	E	45	3	Total-395 VDENT-A-85% (335) SEAR-15% (60)	CLCK-100% (395) DEDS (Legible) • 395 messages • 80 bytes/message avg) System Supervisor • 395 messages • 10 bytes/message	7000	2.0	99.97
CLASS-C	Classification-C	20	E	8	NA	DATE STP-100% (145)	Manual-100% (145)	-	-	-
CLCK	Classification Check	45	E	45	3	Total-1315 VDENT-A-65% (852) CLASS B-307 (395) SEAR-5% (68)	Total-1315 CSORT-79% (1033) AUTOCOR-21% (282) DEDS (Legible) • 1033 messages • 80 bytes/message DEDS (Illegible) • 282 messages • 20 bytes/message System Supervisor (Legible) • 1033 messages • 80 bytes/message System Supervisor (Illegible) • 282 messages • 20 bytes/message TSS • 1033 messages • 80 bytes/message	7000	2.0	99.97
CSORT	Centerline Sort	90	E	12	NA	CLCK-100% (1033)	AFRS-100% (1033) SAR-Few	-	-	-
DATE STP	Date Stamp, Count and Log	1635/day (Documents)	E	1	NA	MAIL-100% (1627/day)	CLASS-C-100% (145)	-	-	-
DENT-A	Data Entry-Cards	30	E	90	6	Total-2254 BLO-32% (720) CLASS-A-40% (1137) ENCK-18% (397)	VDENT-A-100% (2254) DEDS(Search Parameters) • 2254 messages • 160 bytes/message (Avg) System Supervisor • 2254 messages • 10 bytes/message	4000	2.0	99.95
DENT-B	Data Entry-Documents	30 Documents	UNK	42	NA	ENCDOC-100% (1220)	VDENT-B-100% (1220) DEDS(Search Parameters) • 1220 messages • 160 bytes/message System Supervisor • 1220 messages • 10 bytes/message	4000	2.0	99.95

Table A-1. Operational Component Summary (Continued)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- <sup>f</sup> ABILITY
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIS <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
ENC	Encode Input Data-Cards	40	E	60	4	Total-2254 QC-80Z (1805) Manual-20Z (449)	ENCK-100Z (2254)	-	-	-
ENCDOC	Encode Input Data-Documents	35 Documents	UNK	35	NA	Total-1220 READ-87Z (1060) Manual-13Z (160)	ENDOC-100Z (1220)	-	-	-
ENCK	Encode Check-Cards	80	E	30	2	ENC-100Z (2254)	Total-2254 DENT-A-18Z (397) BLO-32Z (720) CLASS-A-50Z (1137)	-	-	-
ENDOCK	Encode Check-Documents	75 Documents	UNK	17	NA	ENDOC-100Z (1220)	DENT-B-100Z (1220)	-	-	-
FLAB	Film Processing/Composer	3000 Card Images		2-Film Proc. 2-Com- poser 2- Fiche Proc.	NA	MFILM-3037 Images	FLOAD-1.5 Fiche (64 copies) PICS • 3037 messages • 6 bytes/message System Supervisor • 3037 messages • 6 bytes/message ICS • 3037 messages • 6 bytes/message	-	-	99.50
FLOAD	Film Load Into Consoles	96 Fiche (2000 Image/ Fiche)	E	1	NA	FLAB-96 Fiche ICS • 1264 messages • 4 bytes/message	ICI-3 Fiche/sta. ICV-3 Fiche/sta. ICS • 64 messages • 4 bytes/message System Supervisor • 64 messages • 4 bytes/message	-	-	-
ICI	Image Comparison Identification	72	E	19	NA	FLOAD-3 Fiche/sta. System Supervisor • 1233 messages • 40 bytes/message ICS • 1233 messages • 40 bytes/message	ICS • 1233 messages • 40 bytes/message System Supervisor (Non Ident) • 390 messages • 40 bytes/message	700	2.0	99.72
ICV	Image Comparison Verification	75	E	13	NA	FLOAD-3 Fiche/sta. ICS • 843 messages • 40 bytes/message	ICS • 843 messages • 40 bytes/message System Supervisor • 843 messages • 40 bytes/message	700	2.0	99.72

Table A-1. Operational Component Summary (Continued)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- ABILITY <sup>f</sup>
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
MAIL	Open Mail and Sort	720	C	6	NA	Post Office 43,677/day • 29,177 F/P Cards • 14,425 Criminal • 13,125 Civil • 1,627 Other • 14,500 Documents • 10,050 Dispositions • 4,450 Misc. Requests	DATE STP-4X (1,627) PCN APP-33X (14,500) PCN-63X (27,550) • Criminal-52X (14,325) • Civil-48X (13,225)	-	-	-
MFILM	Image Capture Microfilm	300	E	6 In- clud- ing 1 square used for temp. hold and perm. file)	NA	Total-3037 PCN-80X (2449) SEAR-10X (294) Temp. hold-10X (294)	Total-3037 QC-80X (2449) Temp. hold-10X (294) Perm. file-10X (294) PICS • 3037 messages • 6 bytes/message System Supervisor • 3037 messages • 6 bytes/message SSRG • 3037 messages • 6 byte/message	Inc.	Inc.	-
PCN	Process Control Number Application - Cards	2000	C	2	NA	MAIL-100X (2449) • Criminal-52X (1282) • Civil-48X (1167) • Rushes-100/day	MFILM-100X (2449) PICS • 70 messages • 6 bytes/message System Supervisor • 70 messages • 6 bytes/message SSRG • 70 messages • 6 bytes/message	2.8 <sup>h</sup> 126 <sup>h</sup>	1.6 <sup>h</sup> 3.4 <sup>h</sup>	99.06 97.38
PCN APPL	Process Control Number Application - Documents	1300 (Documents)	E	1	NA	MAIL-100X (1290)	READ-100X (1290)	-	-	-
QC	Quality Control Check	180	E	14	NA	MFILM-100X (2449) Manual-Few	Total-2450 WAND-262 (645) ENC-742 (1805)	-	-	-
QUERY	On Line Query	10 Calls	E	1	NA	Telephone Requests- 80/day • 10 messages • 100 bytes/message System Supervisor • 10 messages • 100 bytes/message SSRG • 10 messages • 100 bytes/message	DEDS • 10 messages • 20 bytes/message System Supervisor • 10 messages • 70 bytes/message SSRG • 10 messages • 70 bytes/message	7000	2.0	99.97

Table A-1. Operational Component Summary (Cont'd)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- <sup>f</sup> ABILITY
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
READ	Quality Control Check, Read, and Annotate	120 Documents	UNK	11	NA	PCN APPL-100Z (1290)	Total-1296 ENDOC-82Z (1060) AUTOCOR-Manual-18Z (230)	-	-	-
SAR	Semi-Automatic Fingerprint	5	E	7	NA	AFRS-100 (30) CSORT-few TSS (Query) • 30 messages • 6 bytes/message TSS (Minutiae) • 30 messages • 500 byte/message	SEAR-100Z (30) TSS • 30 message • 20 bytes/message System Supervisor • 30 messages • 10 bytes/message	Inc.	Inc.	-
SEAR	Search Review	150	E	15	NA	Total-1972 VDENT-A-48Z (939) AFRS-51Z (1003) SAR-1Z (30) System Supervisor • 1972 messages • 11 bytes/message (Avg) DEDS • 1972 messages • 40 bytes/messages (Avg)	Total-1972 AUTOCOR-24Z (468) CLASS-7-3Z (60) CLCK-3Z (68) MFILA-15Z (204) Archival File-42Z (838) Civil File-12Z (238) Manual-0.3Z (6) DEDS • 3944 messages • 11 bytes/message (Avg) System Supervisor • 3944 messages • 11 bytes/message (Avg) SSRG • 1839 messages • 15 bytes/message (Avg) TSS • 1844 messages • 15 bytes/message (Avg)	7000	2.0	99.97
VDENT-A	Verify Data Entry-Cards	30	E	90	6	DENT-A-(2254) SSRG • 2254 messages • 20 bytes/message System Supervisor • 2254 message • 20 bytes/message DEDS • 2254 messages • 20 bytes/message	Total-2254 CLASS-B-15Z (335) CLCK-38Z (852) SEAR-41Z (939) Civil File-6Z (128) DEDS(Search Parameters) • 2254 messages • 70 bytes/message (Avg)	4000	2.0	99.95



Table A-1. Operational Component Summary (Cont'd)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MTBF <sup>d</sup> (HRS)	MTTR <sup>e</sup> (HRS)	Z AVAIL- ABILITY <sup>f</sup>
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
VDENT-A (Cont)							DEDS (Arrest Data) <ul style="list-style-type: none"> <li>• 2254 messages</li> <li>• 90 bytes/message (Avg)</li> </ul> System Supervisor (Search Parameters) <ul style="list-style-type: none"> <li>• 2254 messages</li> <li>• 70 bytes/message</li> </ul> System Supervisor (Arrest Data) <ul style="list-style-type: none"> <li>• 2254 messages</li> <li>• 90 bytes/message</li> </ul> SSRG(Search Parameters) <ul style="list-style-type: none"> <li>• 2254 messages</li> <li>• 70 bytes/message</li> </ul> SSRG(Arrest Data) <ul style="list-style-type: none"> <li>• 2254 messages</li> <li>• 90 bytes/message</li> </ul> TSS <ul style="list-style-type: none"> <li>• 2254 message</li> <li>• 70 bytes/message</li> </ul>			
VDENT-B	Verify Data Entry-Documents	30 Documents	UNK	42	NA	DENT-B-100Z (1220) SSRG <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 20 bytes/message</li> </ul> System Supervisor <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 20 bytes/message</li> </ul> DEDS <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 20 bytes/message</li> </ul>	Total-1220 AUTOCOR-5Z (60) Manual-95Z (1160) DEDS(Search Parameters) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 70 bytes/message</li> </ul> DEDS(Update Data) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 90 bytes/message</li> </ul> System Supervisor (Search Parameters) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 70 bytes/message</li> </ul> System Supervisor (Update Data) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 90 bytes/message</li> </ul> SSRG(Search Parameters) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 70 bytes/message</li> </ul> SSRG(Update Data) <ul style="list-style-type: none"> <li>• 1220 messages</li> <li>• 90 bytes/message</li> </ul>	4000	2.0	99.95

Table A-1. Operational Component Summary (Continued)

OPERATIONAL COMPONENT		SERVICE		NO. UNITS		INTERFACES <sup>a</sup>		MIBF <sup>d</sup> (HRS)	MITR <sup>e</sup> (HRS)	Z AVAIL- ABILITY <sup>f</sup>
ACRONYM	DESCRIPTION	RATE <sup>a</sup>	DIST <sup>b</sup>	TOTAL	PER WORK CELL	INPUT <sup>c</sup>	OUTPUT <sup>c</sup>			
WAND	Wand Out of System	200	E	5	NA	QC-100Z (545)	Total-645 AUTOCOR-13Z (83) Manual-87Z (562) DEDS • 645 messages • 25 bytes/message System Supervisor • 645 messages • 25 bytes/messages	1500	2.0	99.86

## APPENDIX B

### OPERATIONAL COMPONENT STATIC CAPACITY SUMMARY

Table B-1 reflects a summary of the operational component static capacity analysis. The data contained for each component includes:

#### Acronym:

An abbreviation used in the system to identify an operational component. Table B-1 is in acronym order.

#### Description:

Complete description of each component can be found in Appendix G.

#### Total Required Capability:

The number of units to be processed per hour by the component, based on work load guidelines.

#### Service Rate:

The processing rate of a single unit in the component.

#### Number of Units Proposed:

Number of work stations proposed by Rockwell for the component. If the component is in a work cell, the x figure represents the total number of units, and the y figure represents the number in each of the 15 work cells.

#### Productivity of N Units:

Number of units proposed multiplied by the service rate.

% Space capacity of N Units at 100% Availability equals:

$$\frac{\text{Service Rate} \times \text{N Units (Availability)} - \text{Required Capability} \times 100}{\text{Required Capability}}$$

% Space Capacity of N-1 Units at 100% availability equals:

$$\frac{\text{Service Rate} \times \text{N-1 Units (Availability)} - \text{Required Capability} \times 100}{\text{Required Capability}}$$

#### Calculated % Availability:

The probability that the equipment will perform its intended function when required.

% Space capacity of N Units at calculated availability:

$$\frac{\text{Service Rate} \times \text{N Units (Availability)} - \text{Required Capability} \times 100}{\text{Required Capability}}$$

Table B-1. Operational Component Static Capacity Summary

Operational Component		Total Required Capacity (Cards/Hour)	Service Rate Per Unit Per Hour	Number of Units Proposed (N)	Productivity of N Units Per Hour	X Spare Capacity <sup>a</sup> of N Units at 100% Availability	X Spare Capacity <sup>a</sup> of N-1 Units at 100% Availability	Calculated Z Availability <sup>b</sup>	Z Spare Capacity <sup>a</sup> of N Units at Calculated Availability
Acronym	Description								
AFRS	Automatic Fingerprint Reader System	1,033	210 <sup>c</sup>	5	1,050	1.7	-18.7	95.00 <sup>c</sup> 98.82 <sup>d</sup>	-3.4 0.4
		1,033	315 <sup>e</sup>	5	1,575	52.5	21.9	95.00 <sup>c</sup> 98.82 <sup>d</sup>	44.8 50.6
		1,033	165 <sup>d</sup>	5	825	-20.1	-36.1	95.00 <sup>c</sup> 93.82 <sup>d</sup>	-24.1 -21.1
		1,033	250 <sup>e</sup>	5	1,250	21.0	-3.2	95.00 <sup>c</sup> 98.82 <sup>d</sup>	14.9 19.6
		1,033	195 <sup>f</sup>	5	975	-5.6	-24.5	95.00 <sup>c</sup> 98.82 <sup>d</sup>	-10.3 -6.7
		1,033	293 <sup>e</sup>	5	1,465	41.8	13.5	95.00 <sup>c</sup> 98.82 <sup>d</sup>	34.7 40.1
		1,033	225 <sup>f</sup>	5	1,125	8.9	-12.9	95.00 <sup>c</sup> 98.82 <sup>d</sup>	3.5 7.6
		1,033	338 <sup>e</sup>	5	1,690	63.6	30.9	95.00 <sup>c</sup> 98.82 <sup>d</sup>	55.4 61.7
AUTOCOR	Automated Correspondence	2,410 Pieces	100	25 (Manual)	2,500	3.7	-0.4	-	-
AUTORESP	Automated Response Generation	2,000 Output Documents	Inc.	26	-	-	-	-	-
BLO	Blocking Out [Per Work Cell]	48	50	30/2*	100*	108.3*	4.2*	-	-
CLASS-A	Classification-A [Per Work Cell]	75	10	120/8*	80*	6.7*	-6.7*	99.97	6.6*
CLASS-B	Classification-B [Per Work Cell]	26	10	45/3*	30*	15.4*	-23.1*	99.97	15.4*
CLASS-C	Classification-C	145	20	8 (Manual)	160	10.0	-3.4	-	-

\*Per Work Cell

<sup>a</sup> Percent Spare Capacity =  $\frac{\text{Service Rate} \times \text{N Units (Availability)} - \text{Required Capacity}}{\text{Required Capacity}} \times 100$ 

- Negative Figures Indicate Insufficient Units to Handle Required Capacity
- 0.0% Spare Capacity Indicates Marginal Feasibility

- <sup>b</sup> Does not include interfacing computer subsystem availability data.
- Does not include transportation system availability data.

<sup>c</sup> Rockwell Data<sup>d</sup> JPL Study Data<sup>e</sup> Previous Service Rate Increased 50 Based on Rockwell Proposed AFRS Modifications<sup>f</sup> FBI Guideline: 210 ± 15<sup>g</sup> \*g data on this line is stated on a work cell basis<sup>h</sup> Spare Machine Used to Process 588 Temporary and Permanent Data Additions Per Hour.B-3  
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Table B-1. Operational Component Static Capacity Summary (Continued)

Operational Component		Total Required Capability (Cards/Hour)	Service Rate Per Unit Per Hour	Number of Units Proposed (N)	Productivity of N Units Per Hour	X Spare Capacity <sup>a</sup> of N Units at 100% Availability	X Spare Capacity <sup>a</sup> of N-1 Units at 100% Availability	Calculated X Availability <sup>b</sup>	X Spare Capacity <sup>a</sup> of N Units at Calculated Availability
Acronym	Description								
CLCK	Classification Check [Per Work Cell]	88	45	45/3*	135*	53.4*	2.2*	99.97	53.4*
CSORT	Centerline Sort	1,033	90	12	1,080	4.5	-4.2	-	-
DATESTP	Date Stamp, Count and Log	1,635	1,635	(Manual)	1,635	0.0	-100.0	-	-
DENT-A	Data Entry-Cards [Per Work Cell]	150	30	90/6*	180*	20.0*	0.0*	99.95	19.9*
DENT-B	Data Entry-Documents	1,220	30	42	1,260	3.3	0.8	99.95	3.2
ENC	Encode Input Data-Cards [Per Work Cell]	150	40	60/4* (Manual)	160*	6.7*	-20.0*	-	-
ENCDOC	Encode Input Data- Documents	1,220	35	35 (Manual)	1,225	0.4	-2.5	-	-
ENCK	Encode Check-Cards [Per Work Cell]	150	80	30/2	160*	6.7*	-46.7*	-	-
ENDOCK	Encode Check-Documents	1763	75	17 (Manual)	1,275	4.5	-1.6	-	-
FLAB	Film Processing/Composer	3,000 Card Images	3,070	2	6,140	104.7	2.3	99.50	101.5
FLOAD	Film Load Into Consoles	96 Fiche	96	1 (Manual)	96	0.0	-100.0	-	-
ICI	Image Comparison Identification	1,233 Images	72	19	1,368	10.9	5.1	99.72	10.6
ICV	Image Comparison Verification	843 Images	75	13	975	15.7	6.8	99.72	15.3
MAIL	Open Mail and Sort	43,677 Pieces/Day	720	6 (Manual)	48,600 Per Day	11.3	-7.3	-	-
MFILM	Image Capture Microfilm	2,449 3,037 <sup>h</sup>	600 600	5 <sup>h</sup> 6 <sup>h</sup>	3,000 3,600	22.5 18.5	-2.9 -1.7	99.96 99.96	22.4 18.5
PCN	Process Control Number Application-Cards	2,449	2,000	2	4,000	63.3	-18.3	99.86 <sup>c</sup> 98.13 <sup>d</sup>	61.8 60.1
PCN APP	Process Control Number Application-Documents	1,290 Documents	1,300	1 (Manual)	1,300	0.0	-100.0	-	-

Table B-1. Operational Component Static Capacity Summary (Continued)

Operational Component		Total Required Capability (Cards/Hour)	Service Rate Per Unit Per Hour	Number of Units Proposed (N)	Productivity of N Units Per Hour	Z Spare Capacity <sup>a</sup> of N Units at 100% Availability	Z Spare Capacity <sup>a</sup> of N-1 Units at 100% Availability	Calculated Z Availability <sup>b</sup>	Z Spare Capacity <sup>a</sup> of N Units at Calculated Availability
Acronym	Description								
QC	Quality Control Check	2,449	180	14	2,510	2.9	-4.5	-	-
QUERY	On-Line Query	80 Calls/Day	10	1	113 Per Day	48.6	-100.0	99.97	48.6
READ	Quality Control Check, Read, and Annotate	1,290	120	11 (Manual)	1,320	2.3	-7.0	-	-
SAR	Semi-Automatic Finger- print Reader	30	5	7	35	16.7	0.0	Inc.	-
SEAR	Search Review	1,972	150	15	2,250	14.1	6.5	99.97	14.1
VDENT-A	Verify Data Entry-Cards [Per Work Cell]8	150	30	90/6*	180*	20.0*	0.0*	99.95	19.5*
VDENT-B	Verify Data Entry-B Document	1,220	30	42	1,260	3.3	0.8	99.95	3.2
WAND	Wand Out of System	645	200	5	1,000	55.0	24.0	99.86	54.8
-	Work Cell	2,382 (Inc. 128 from SEAR)	159	15	2,385	0.0	-6.5	-	-

## APPENDIX C

### ESTIMATED OPERATIONAL COMPONENT/COMPUTER SUBSYSTEM DATA TRANSFER REQUIREMENTS

Data contained in Table C-1 reflects an estimate by JPL of the relative scope of the hourly message volumes and related record sizes that are proposed to be transferred between operational components and the computer subsystems.



Table C-1. Estimated Operational Component/Subsystem Data Transfer Requirements

OPERATIONAL COMPONENT	PCN AND IMAGE CAPTURE SUBSYSTEM		DATA ENTRY AND DISPLAY SUBSYSTEM		SUBJECT SEARCH AND RESPONSE GENERATION SUBSYSTEM		TECHNICAL SEARCH SUBSYSTEM		IMAGE COMPARISON SUBSYSTEM		SYSTEM SUPERVISOR			
											RECEIVED		SENT	
ACRONYM	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR	# MESS PER HR	# BYTES PER HR
AFRS							1,033	2,066,000			1,033	10,330*		
AUTORESP					1,517	60,680							1,517	60,680
CLASS-A			1,137	90,960							1,137	11,370*		
CLASS-B			395	31,600							395	3,950*		
CLCK			1,315	88,280			1,033	82,640			1,315	88,280	1,033	82,640
DENT-A			2,254	360,640							2,254	22,540*		
DENT-B			1,220	195,200							1,220	12,200*		
FLAB	3,037	18,222							3,037	18,222	3,037	18,222	3,037	18,222
FLOAD									128	512	64	640*		
ICI									2,466	98,640	390	15,600	1,233	49,320
ICV									1,646	67,440	843	33,720		
INFLIN	3,037	18,222			3,037	18,222					3,037	18,222	3,037	18,222
PCN	70	420			70	420					70	420	70	420
QUERY			20	1,700	20	1,700					20	1,700	20	1,700
SAR							90	15,780			30	300*		
SEAR			5,916	119,402	1,839	27,210	1,844	27,410			3,944	40,522*	1,972	78,880
VDENT-A			6,752	405,720	4,508	360,640	2,254	157,780			4,508	360,640	4,016	561,500
VDENT-B			3,660	219,600	3,660	219,600					3,660	219,600	3,660	219,600
WAND			645	16,125							645	16,125		
SUBSYSTEM TO/FROM SS					6,948	93,880	2,066	264,448			9,014	158,328		
• MANAGEMENT RPT											Not Specified		Not Specified	
• COMPONENT STATUS											Not Specified		Not Specified	
• FACILITY STATUS											Not Specified		Not Specified	
SUBTOTAL											36,626	852K	24,595	1,203K
TOTALS BY SUBSYSTEM	6,144	37K	23,324	1,529K	21,599	783K	8,320	1,614K	7,207	185K	61,221 messages		2,055K bytes	
ESTIMATED INTERNAL PROCESSING REQUIREMENTS	100 KIPS		500 KIPS (NOT INC FOUR-PHASE)		1,250 KIPS		1,200 KIPS		250 KIPS				250 KIPS	
SUBSYSTEM TO SYSTEM SUPERVISOR INTERFACES	1 Line 600 Baud		14 Lines 600 Baud		1 line 800 Baud		1 line 600 Baud		1 line 600 Baud				17 Lines 600 Baud 1 line 800 Baud	

\*Status Update PCN &amp; Work Station Identification Estimated at 10 Bytes per Message

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## APPENDIX D

### DATA SOURCES

The rates used in the evaluation process were from various sources with varying degrees of consistency and rationale. Where a derivation of the rate was provided by Rockwell, this is so noted. Estimates by JPL based on Rockwell data or arrived at from other than Rockwell sources are also noted. If no remark is made, the rationale or derivation for the data stated in the reference was not specifically identified.

Data sources are listed in this Appendix for:

- (1) Number of Work Stations
- (2) Service Rates
- (3) Service Rate Distribution Function
- (4) Card/Document Volumes and Routing Distribution
- (5) Maintenance
- (6) Data Transfer Message Volumes and Size

#### A. Number of Work Stations

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
AFRS	Automated Fingerprint Reader System	Reference 23, Page 4
AUTOCOR	Automated Correspondence	Reference 7, Page 6
AUTORESP	Automated Response Generation	Reference 6, Page 16
BLO	Blocking Out	Reference 8, Page 26
CLASS-A	Classification-A	Reference 8, Page 26
CLASS-B	Classification-B	Reference 8, Page 26
CLASS-C	Classification-C	Reference 1, Page 4-7
CLCK	Classification Check	Reference 8, Page 26
CSORT	Centerline Sort	Reference 7, Page 6
DATE STP	Date Stamp, Count and Log	Reference 7, Page 6
DENT-A	Data Entry-Cards	Reference 8, Page 26
DENT-B	Data Entry-Documents	Reference 7, Page 6
ENC	Encode Input Data-Cards	Reference 8, Page 26
ENCDOC	Encode Input Data-Documents	Reference 7, Page 6
ENCK	Encode Check-Cards	Reference 8, Page 26
ENDOCK	Encode Check-Documents	Reference 7, Page 6
FLAB	Film Processing/Composer	Reference 2, Page 57
FLOAD	Film Load Into Consoles	Reference 1, Page 6-41
ICI	Image Comparison Identification	Reference 7, Page 6
ICV	Image Comparison Verification	Reference 7, Page 6
MAIL	Open Mail and Sort	Reference 7, Page 6
MFLIM	Image Capture Microfilm	Reference 7, Page 6
PCN	Process Control Number Appl-Cards	Reference 7, Page 6
PCN APPL	Process Control Number Appl-Documents	Reference 7, Page 6
QC	Quality Control Check	Reference 7, Page 6
QUERY	On-Line Query	Reference 7, Page 6
READ	Quality Control Check, Read, and Annotate	Reference 7, Page 6

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
SAR	Semi-Automatic Fingerprint Reader	Reference 1, Page 6-12 Rockwell, experience
SEAR	Search Review	Reference 7, Page 6
VDENT-A	Verify Data Entry-Cards	Reference 8, Page 26
VDENT-B	Verify Data Entry-Documents	Reference 7, Page 6
WAND	Wand Out of System	Reference 7, Page 6
-	Work cell	Reference 8, Page 27

**B. Service Rate**

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
AFRS	Automated Fingerprint Reader System	JPL Studies and Reference 6, page 12 - See Appendix F
AUTOCOR	Automated Correspondence	Reference 8, Page 13 - engineering estimate
AUTORESP	Automated Response Generation	Reference 7, Page 6
BLO	Blocking Out	Reference 8, Page 13 - Test results of 75 cards/hour derated to 50 C/H to allow designation of possible illegibles. Based on measurements from similar functions.
CLASS-A	Classification-A	Reference 8, Page 13 - FBI Standard for full Henry Classification
CLASS-B	Classification-B	Reference 8, Page 13 - FBI Standard for full Henry Classification
CLASS-C	Classification-C	Reference 1, Page 4-7
CLCK	Classification Check	Reference 8, Page 13 - FBI-supplied estimate of current performance
CSORT	Centerline Sort	Reference 5, Page 9 - Time and motion estimate and file conversion
DATE STP	Date Stamp, Count and Log	Reference 7, Page 6

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
DENT-A	Data Entry-Cards	Reference 8, Page 13 - Based on 4800 key- strokes/hour and 160 character/card
DENT-B	Data Entry-Documents	Reference 8, Page 13 - Based on 4800 key- strokes/hour and 160 character/card
ENC	Encode Input Data-Cards	Reference 8, Page 13 - FBI-supplied estimate based on AIDS I performance
ENCDOC	Encode Input Data-Documents	Reference 5, Page 10 - Estimated
ENCK	Encode Check-Cards	Reference 8, Page 13 - FBI-supplied estimate based on AIDS I performance
ENDOCK	Encode Check-Documents	Reference 8, Page 13 - Estimated
FLAB	Film Processing/Composer	Reference 6, Page 8
FLOAD	Film Load Into Consoles	Reference 7, Page 6
ICI	Image Comparison Identification	Conflicting data was presented in Refer- ence 2, Page 86 (Studies), Refer- ence 5, Page 10 (which references Ref- erence 2, Page 86), and Reference 7, Page 6. The service rate stated in Refer- ence 7, Page 6 was selected as being a reasonable compromise between the conflict- ing data.
ICV	Image Comparison Verification	
MAIL	Open Mail and Sort	Reference 8, Page 13 - Engineering estimate
MFLIM	Image Capture Microfilm	Reference 5, Page 10 - Model M600W/PCN Mods.

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
PCN	Process Control Number Appl-Cards	Reference 7, Page 13 - Derated from design rating
PCN APPL	Process Control Number Appl-Documents	Reference 8, Page 13 - FBI-supplied estimate
QC	Quality Control Check	Reference 8, Page 13 - FBI-supplied estimate
QUERY	On-Line Query	Reference 5, Page 10 - AIDS II experience
READ	Quality Control Check, Read, and Annotate	Reference 5, Page 10 - Estimated
SAR	Semi-Automatic Fingerprint Reader	Reference 8, Page 13 - Rockwell experience on Rockwell's terminal used in latent print processing
SEAR	Search Review	Reference 8, Page 13 - Engineering estimate
VDENT-A	Verify Data Entry-Cards	Reference 8, Page 13 - Based on 4800 key- strokes/hour and 160 characters/docu- ment
VDENT-B	Verify Data Entry-Documents	Reference 8, Page 13 - Based on 4800 key- strokes/hour and 160 characters/docu- ment
WAND	Wand Out of System	Reference 8, Page 13 - Engineering estimate
-	Work Cell	JPL estimate based on detailed analysis of card routing distri- bution shown in Figure E-1

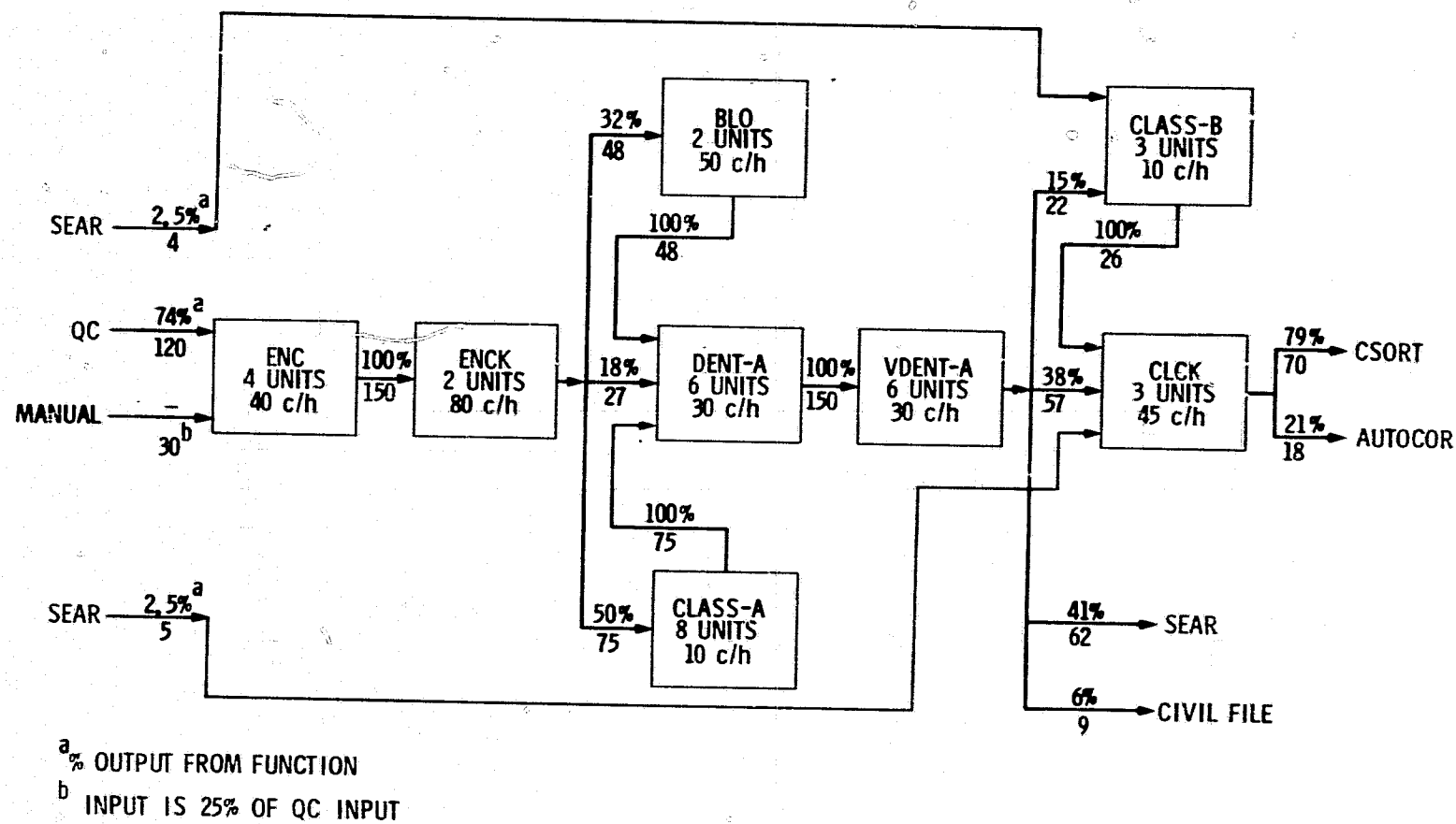


Figure D-1, Work Cell Card Flow

C. Service Rate Distribution Function

In all cases where the service rate distribution function is used, it was obtained from Reference 8, Page 13.

D. Card/Document Volumes and Routing Distribution

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
AFRS	Automated Fingerprint Reader System	Reference 7, Page 6
AUTOCOR	Automated Correspondence	Reference 7, Page 6
AUTORESP	Automated Response Generation	Reference 7, Page 6
BLO	Blocking Out	Reference 7, Page 6
CLASS-A	Classification-A	Reference 7, Page 6
CLASS-B	Classification-B	Reference 7, Page 6
CLASS-C	Classification-C	Reference 1, Page 4-7
CLCK	Classification Check	Reference 7, Page 6
CSORT	Centerline Sort	Reference 7, Page 6
DATE STP	Date Stamp, Count and Log	Reference 7, Page 6
DENT-A	Data Entry-Cards	Reference 7, Page 6
DENT-B	Data Entry-Documents	Reference 7, Page 6
ENC	Encode Input Data-Cards	Reference 7, Page 6
ENCDOC	Encode Input Data-Documents	Reference 7, Page 6
ENCK	Encode Check-Cards	Reference 7, Page 6
ENDOCK	Encode Check-Documents	Reference 7, Page 6
FLAB	Film Processing/Composer	Reference 7, Page 6 and Reference 8, Page 16
FLOAD	Film Load Into Consoles	Reference 7, Page 6
ICI	Image Comparison Identification	Reference 7, Page 6
ICV	Image Comparison Verification	Reference 7, Page 6
MAIL	Open Mail and Sort	Reference 7, Page 6
MFLIM	Image Capture Microfilm	Reference 7, Page 6
PCN	Process Control Number Appl-Cards	Reference 8, Page 6 See Note A
PCN APPL	Process Control Number Appl-Documents	Reference 7, Page 6
QC	Quality Control Check	Reference 7, Page 6
QUERY	On-Line Query	Reference 7, Page 6
READ	Quality Control Check, Read, and Annotate	Reference 7, Page 6
SAR	Semi-Automatic Fingerprint Reader	Reference 7, Page 6
SEAR	Search Review	Reference 7, Page 6
VDENT-A	Verify Data Entry-Cards	Reference 7, Page 6
VDENT-B	Verify Data Entry-Documents	Reference 7, Page 6
WAND	Wand Out of System	Reference 7, Page 6

NOTE A: - There is a conflict between Reference 7, Page 6, Reference 8, Page 9 and Reference 10, Page 9, concerning the mix of input cards. Data from References 7 and 8 was used as it was the most consistent.

#### E. Maintenance

Mean-Time-Between-Failures and Mean-Time-to-Repair data was not identified by specific source or related to a specific operational component.

The evaluation team used its best judgment based on the generic data presented to relate the data to the operational component.

Mean-Time-to-Respond was stated in Reference 5, Page 47, to be 1.0 hour. In determining Mean-Time-to-Restore, this hour was added to all Mean-Time-to-Repair data.

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
AFRS	Automated Fingerprint Reader System	JPL Study - Appendix H
AUTORESP	Automated Response Generation	Reference 24, Page 8
CLASS-A	Classification-A	Reference 24, Page 8
CLASS-B	Classification-B	Reference 24, Page 8
CLCK	Classification Check	Reference 24, Page 8
DENT-A	Data Entry-Cards	Reference 1, Page 6-85
DENT-B	Data Entry-Documents	Reference 24, Page 8
FLAB	Film Processing/Composer	Reference 1, Page 6-87 - Configured for on-line backup
ICI	Image Comparison Identification	Reference 24, Page 6-8
ICV	Image Comparison Verification	Reference 24, Page 6-8
MFLIM	Image Capture Microfilm	Reference 24, Page 8
PCN	Process Control Number Appl-Cards	JPL Study - Appendix H
QUERY	On-Line Query	Reference 24, Page 8
SAR	Semi-Automatic Fingerprint Reader	---
SEAR	Search Review	Reference 24, Page 8
VDENT-A	Verify Data Entry-Cards	Reference 1, Page 6-82
VDENT-B	Verify Data Entry-Documents	Reference 24, Page 8
WAND	Wand Out of System	Reference 24, Page 8

#### F. Data Transfer Message Volumes and Size

The subsystem interfaces between the operational components and the various subsystems were derived from Reference 6, page 16, and the various subsystem descriptions found in References 1, 6 and 7.

The message volumes between the operational components and the computer subsystems were derived from the source indicated in Paragraph E above, Card/Document Volumes and Routing Distribution.

When the operational component transmitted only PCN status accounting information, to the System Supervisor, a value of 10 bytes/message was assumed.



Other message sizes were obtained from the following sources:

<u>Acronym</u>	<u>Description</u>	<u>Source</u>
AFRS	Automated Fingerprint Reader System	Reference 6, Page 26-17
AUTORESP	Automated Response Generation	Reference 7, Page 6 and JPL estimates
CLASS-A	Classification-A	Reference 6, Page 21
CLASS-B	Classification-B	Reference 6, Page 21
CLCK	Classification Check	Reference 6, Page 21
DENT-A	Data Entry-Cards	Reference 8, Page 13
DENT-B	Data Entry-Documents	Reference 5, Page 10 and Reference 8, Page 13
FLAB	Film Processing/Composer	Reference 6, Page 19
FLOAD	Film Load Into Consoles	Reference 1, Page 6-41 and JPL extrapolation
ICI	Image Comparison Identification	Reference 2, Page 106
ICV	Image Comparison Verification	Reference 2, Page 106
MFLIM	Image Capture Microfilm	Reference 6, Page 19 and Reference 2, Page 106
PCN	Process Control Number Appl-Cards	Reference 6, Page 19
QUERY	On-Line Query	JPL estimate based on DENT and VDENT data
DENT		JPL estimates based on the number of fingers to be encoded (2) and 250/bytes finger
SAR	Semi-Automatic Fingerprint Reader	JPL estimates based on the data requirements of the various status conditions of the cards and extrapolations from previously documented processing information
SEAR	Search Review	Reference 8, Page 13
VDENT-A	Verify Data Entry-Cards	Reference 5, Page 10 and Reference 8, Page 13
VDENT-B	Verify Data Entry-Documents	Reference 8, Page 13
WAND	Wand Out of System	Reference 6, Page 20

## APPENDIX E

### SPECIAL FINGERPRINT CLASSIFICATION TERMINAL

The fingerprint classification terminal requires more study and testing before a commitment to its use is made. There are two basic design alternatives for this station. The first combines the classification process with the data entry process, while the second breaks out the data entry as a separate position. Appendix E addresses the human factors for these alternatives, as well as the design of the proposed terminal itself. This decision will be based on the classification work station processes described in Reference 1. The human factors will be identified and analyzed, and both advantages and disadvantages of the alternatives will be addressed.

If it is decided that the Special Classification Terminal is to be implemented, wholly or partially, there are concerns with the keyboard design regarding data entry errors that it might promote.

#### A. CLASSIFICATION/DATA ENTRY FUNCTIONS

##### 1. Task Analysis

The fingerprint classification process consists of the following individual tasks:

- (1) Fingerprint analysis and classification - Specific characteristics of each print on the fingerprint card are translated into an alphanumeric code. The throughput summary (Reference 1) indicates an expected 10 documents per hour. After removing the time required for data entry, this translates into an average of one fingerprint card every 5 minutes and 30 seconds.
- (2) Classification data entry - The classification codes are entered into a data entry terminal for storage in the system. Assuming that each classification code is 2 characters (for a total of 20 characters), and using the card keystroke model (Reference 37), the time required to enter the PCN and classification codes is estimated at 30 seconds.
- (3) Classification data entry verification - The codes entered into the data entry terminal are verified on the CRT screen before transmitting it to the System Supervisor.

##### 2. Work Station Configuration Alternatives

The work station alternatives are the one-position work station and two-position work station. In the one-position work station, the

technician classifies each fingerprint and keys the classifications into a data entry terminal. The two-position work station separates the classification and data entry tasks.

Following are comments on pertinent issues:

- (1) Closure - Closure is the technical term for the degree of satisfaction felt by an individual after completing a task. A task with high closure is one in which the completion is clear and well identified. A task with low closure is one in which the completion of the task is not clear. The classification task probably has a medium level of closure. The closure for the classification task is the completion of the classification codes. The closure for the data entry is the completion of the input keystrokes. Closure for the data entry verification is when the visual data check is complete and the card complete key is hit. We can expect the closure for the data entry tasks to be lower than for the classification task. It is not clear that the combined tasks of classification and data entry have any higher level of closure than the individual tasks.
- (2) Compatibility - The issue here is the compatibility between the classification task and the data entry task. The two tasks are essentially independent. Although they are not totally incompatible, there is very little similarity between the tasks, and no reason to combine the two for compatibility.
- (3) Error Detecting - Combining the classification and data entry tasks increases the error detecting capability of the work station. For data verification tasks, the operator/technician can relate the entered data back to the original source, the fingerprint, making it easier to recognize an erroneous data entry. For the two-position work station, the data entry and verification tasks are separated from the original data in the classification task. Therefore, the data entry operator can only relate back to the intermediate (handwritten) data. The data entry operator did not participate in the original classification code generation, and therefore does not have a feeling for the validity of the entered data.

The advantages of increased error detection capability is reduced in the one-position work station, since the classification verification work station is expected to detect data entry errors as well as classification errors. It is conceivable that the increased error detection of the one-position work station would allow a reduction in the number of classification verification stations, but it is not likely to be significant.

- (4) Skills - The classification technician is trained in the skill of classifying finger/prints using a particular method. The skills required to enter the data into a terminal are quite different. There is no advantage to combining these tasks in terms of skill compatibility. There is merit in separating the task assignments, in order to capitalize on skill specialization in maximizing throughput.
- (5) Learning - Because the classification and data entry tasks are different, the learning (or training) process is complicated. With separated positions (two-position work stations), the technician is not burdened with having to learn the data entry tasks at the same time as he is learning the classification task. This may not be significant, as the data entry task would probably be fairly easy for a technician. In any event, separating the tasks would reduce the learning load on the technician.
- (6) Job Variety - The two-position work station does provide a modicum of job variety for the classification technician. Data entry and verification tasks require different activities. It is not clear whether this would be regarded as a welcome relief or as an added burden. Direct measurement would be required to determine how classification technicians would react to this issue. Most likely, the lower skill level of the data entry task would provide little in the way of satisfactory job variety. The separated (two-position) work station would provide another type of data entry task, which might provide more job variety for the operator.
- (7) Economics - There may be a cost savings in a two-position work station configuration. In the two-position configuration, the classification task becomes completely manual in nature, and all mechanical and electronic equipment can be eliminated. The data entry task can be accomplished with fewer terminals, although additional personnel may be required. The economic aspects require additional study, as the concerns for data entry following the CLASS-A function are different than those following CLASS-B and CLCK.

### 3. Advantages/Disadvantages of Configuration Alternatives

The one-position work station has an advantage in increased error detection for the data entry task. It may have a disadvantage, however, in the economics and training areas. No advantage or disadvantage is seen with closure, job variety, or job skills issues.

The two-position work station may have advantages from an economic and training standpoint. There are some advantages in the areas of skill level and job variety. The only disadvantage to this configuration is in error detection, which is mitigated by the classification verification function (expected to uncover data entry errors as well as classification errors).

#### 4. Recommendations

The two-position classification work station, in which classification and data entry tasks are separated, is strongly recommended for further analysis and study from both the human and economic standpoints.

#### B. SPECIAL CLASSIFICATION KEYBOARD

The decision to use a special keyboard design (i.e., differing radically from a conventional typewriter or QWERTY keyboard), should be based on an analysis of the specific tasks to be accomplished and the characteristics of the special keyboard. The special keyboard must offer significant advantages over a conventional keyboard format to warrant its use. General task requirements include the manual identification of specific fingerprint characteristics, converting them to a code, entering the code on the fingerprint card and entering the code into the computer system. Functionally, it is assumed that the major amount of time will be spent in encoding the fingerprints. Some time is required to enter the codes through the keyboard, and more time is required to verify the codes on the display. The principal areas of operator attention are the fingerprint cards with individual prints, the keyboard, and the data display on the terminal.

The encoding process is beyond the scope of this critique; it is primarily a customer skill. The verification process should be straightforward, since the display format is well suited to that application. It provides compatibility between the encoded display and the original fingerprint card, reducing any adjustment required by the operator when going from the display to the fingerprints.

##### 1. Data Entry Methodology

It would be advantageous if the data entry procedure were an overlearned process (e.g., touch-typing). If data entry is an overlearned process, the operator has only two centers of attention: the fingerprint and the coded display. If it is not an overlearned process, the operator has three centers of attention. In addition to the fingerprint and coded display, he must also think about the keyboard.

Overlearning is a process that requires training and practice. Ease of learning depends on the compatibility between the operator and the process (Reference 32). The amount of training and practice required depend upon the following compatibility factors: mechanical, conceptual and spatial. Mechanical compatibility concerns the ability of an operator to physically accomplish the task. Conceptual compatibility is when the process feels natural to the operator (this may be due to some inherent quality, cultural background, or a previously learned experience). Spatial compatibility concerns the similarity of physical arrangement between different elements of a process.

## 2. Special Terminal Keyboard Layout

It is interesting to compare the proposed special keyboard with the conventional QWERTY keyboard in the context of the previously outlined task scenario. Since 1975, society has had a great deal of experience with QWERTY keyboards. Investigations have indicated that, although it may not be the optimum, it is sufficiently close. The conventional keyboard fits the line of the fingers, and the keys are comfortably spaced. With the touch system, each finger has to move only two rows up, one row down, and one key to each side (each finger is responsible for a limited number of keys). With a shift key, the entire ASCII character set is available. This large character set allows flexibility in the man/computer interface dialogue, which can accommodate future expansions or changes in the basic process. With operators trained in the touch-typing system, the QWERTY keyboard has conceptual compatibility; they are familiar with it. Even operators who have not had typing training and who use the hunt-and-peck system find the QWERTY keyboard familiar. Although the QWERTY keyboard does not have spatial compatibility with the fingerprint classification process, this is not important since, in an overlearned system, the physical configuration of the keyboard does not require attention. What is important is that the man/computer dialogue design should be conceptually compatible with the fingerprint classification process. The QWERTY keyboard requires two hands, which could be a disadvantage in some situations.

We have had no experience in using the special keyboard, so we do not know whether it is better suited to this specific function or not. However, we can analyze it as we did the QWERTY keyboard. The physical arrangement of the special keyboard is not mechanically compatible with the human hand, and the keys appear to be very close together. The keyboard does not provide a reference key for hand placement to support touch typing. It appears that the special keyboard also requires two hands. Hand placement for touch-typing on the special keyboard is closer than is required on the QWERTY keyboard.

Reference 1 states that the special keyboard complements the classification function by providing a finger-block display layout, similar to that of the fingerprint card, and special-purpose keys to input preferred finger classifications and references. The display is

both conceptually and spatially compatible with the fingerprint card, but this does not apply to the keyboard. The keyboard layout is not related to the card layout. The key labels are conceptually compatible with the fingerprint classification process (good for a hunt-and-peck typing system), but this is immaterial for an overlearned or touch-typing system. For a touch-typing system, the key position is the important issue. The special-function keys are appropriate when a limited number of functions are to be selected. Nominally, the limit is on the order of seven functions. This seems to be the largest number of functions that the general population can easily distinguish (Reference 33). The proposed special keyboard contains more than seven special function keys, and these are mixed with transaction keys such as "Card Complete," "Clear Card," etc., which increases the difficulty of using the keyboard.

The numerical keyboard is a telephone-style format. This may create some serious compatibility problems. The telephone format places the number 1 in the upper left of the numeric keyboard with 2 and 3 to the right, and 4 through 9 below. The most-used alternate numeric keyboard configuration is the calculator format, where 1 is placed on the lower left, 2 and 3 on the right, and the remaining numbers above. The specific difficulty with the telephone-style numeric keyboard is that it is not compatible with the calculator-style keyboard. Even though touch-tone telephones employing the telephone-style keyboard are becoming more common, calculators are also widely used (especially in business). Also, the data entry function is conceptually compatible with the calculator function (rather than the telephone-number-selection function). Standard keyboards on available computer terminals usually use the calculator style for the numeric keyboard. Having two different styles increases the difficulty of rotating operators within work stations for training and upgrading of personnel.

The location of the "Enter" key creates another conceptual compatibility problem. This key signifies the completion of a data element. On a typewriter, the same basic function is a carriage return. On calculators, it is "=", "&", and ".". All of these keys are to the right of the data keys. The more normal keyboard characteristic is to use the little finger of the right hand for this function. The special keyboard places the "Enter" key below and to the left of the numeric keyboard. This implies that the first or second index finger would be used, which is clearly incompatible with other data-entry activities. Again, this might create transaction problems in rotating operators within work stations, and training problems for new or upgraded operators.

Frequency of errors is another issue that needs addressing. When a data-entry system incorporates a significant possibility of an operator error, the system performance is reduced. If the operator feels that he must be very careful to avoid making an error, he must then work at a slower, more deliberate pace. If the operator inadvertently hits the "Clear Card" key while expecting to hit one of the others in the normal data-entry process, his previous work will be cleared. This is quite frustrating, and recovery is time-consuming.

The same comment applies to the "Sign Off" key, which is located next to the "9" key. A slight mistake, and the work station is disconnected from the computer.

If a special keyboard is used, it is suggested that the keys providing different functions be physically separated. The data entry keys should be located together for a smooth, key-stroke flow. The error-recovery keys ("Clear Card," "Clear Entry," etc.) should be physically separated from the data-entry keys and the system-function keys ("Log On" and "Sign Off") should be together but separated from the other keys. The "Card Complete" key should be separated from the other keys. Its function is to terminate the individual card transaction, and it is initiated after the data has been entered and verified. This expanded configuration would localize functions for better comprehension and use, reduce errors due to misplaced key-strokes, and reduce the distraction of keys demanding the operator's attention around the data-entry keys, making the keyboard easier to use.

A back space key should be included for error recovery. Clearing the entire entry to a clear a character error is a drastic action which becomes especially frustrating when an error is near the end of the data item.

In conclusion, it is not clear that a data-entry terminal is appropriate for this application. If one is used, the keyboard design should be improved to increase performance and reduce error rates.

ORIGINAL PAGE IS  
OF POOR QUALITY



## APPENDIX F

### AUTOMATIC FINGERPRINT READER SYSTEM (AFRS) SERVICE RATE

#### A. SERVICE RATE USED FOR EVALUATION

Various service or throughput rate capabilities for the Automatic Fingerprint Reader System (AFRS) function have been stated. Reference 7, Page 6 indicates a value of 210 cards/hour. The FBI Guidelines to Rockwell (Reference 8, Page 13) indicate a range of 210  $\pm$  15 cards/hour (i.e., between 195 and 225 cards/hour). JPL studies indicate a throughput capacity range of from 107 to 176 cards/hour with a weighted average of 165 cards/hour (Reference 19). This rate equates rather well to the overall fingerprint file conversion effort average rate of 18,000 cards/day (Reference 35). Using 165 cards/hour as a basic service rate, and assuming the successful implementation of a 50% AFRS productivity increase as a result of the modification proposed by Rockwell (Reference 6), a service rate of 250 cards/hour was used in evaluation of the AFRS component. Appendix B reflects the details of the static analysis on the AFRS function for the varying service rates.

The results of the JPL study (discussed in Paragraph B) were based on data gathered from actual FBI worklogs processed by all five AFRSs for the file conversion effort (i.e., reading all fingerprint cards on file with subject date of birth 1929 and later, and storing the minutiae data for use in Technical Search when AIDS III is implemented). This conversion required reading several different versions of the fingerprint card used over the years. Many of the cards processed were dog-eared, frayed and required mending to process them through the AFRSs.

Rockwell has stated (Reference 6, Page 12) that, for a modest additional investment, the minutiae detection processor can be included in the hardware, increasing the throughput by 50%. According to Rockwell, this modification has already been made on some of their equipment, and a 50% improvement was seen. This has not yet been demonstrated in a production environment to the JPL evaluation team. Estimated costs for such a modification are included in the AIDS III capital cost estimates.

The use of a service rate of 250 cards/hour provides a 21.0% spare capacity with all five AFRSs in operation. With only four AFRSs operating, a -3.2% capacity is experienced. Results of the simulation model show that the 250 cards/hour rate does not adversely impact the ability of the system to process cards in a given period of time at the 1993 workload, with a 50/50 (criminal vs civil) mix.

The ongoing operability of the AFRSs as they age could become a problem. From an operability viewpoint, the primary concern in this function is cards jamming due to their poor physical condition. The

card dejamming procedure described on page 1-218 of the Calspan manual (Reference 20) is complex and time-consuming. The procedure has been substantially modified in the Rockwell-designed production AFRSs (Reference 22, Page 4-2). Malfunctioning of the card hopper is usually caused by an accumulation of paper dust, which can be avoided by routine cleaning. The quality and newness of the inquiry fingerprint cards should greatly reduce this problem.

#### B. MEASUREMENT OF AFRS SERVICE RATE

To measure the AFRS production rate, statistics were taken from the Automation and Research (A&R) Finder Room production data log (Reference 19). The sample size used was 53 work periods distributed among day, night and midnight shifts. The duration of each shift was 7.5 hours. Samples were picked at random from the months of September, October, November and December 1979.

The criteria used to reject a sample were:

- (1) When an AFRS was not operational because of lack of work.
- (2) When no report was generated for a specific AFRS.
- (3) When an AFRS was used for pilot test activity.

The statistics generated were weighted by sample size to reduce the degree of bias.

The computation of the mean production rate yielded 165 fingerprint cards/AFRS/hr.

The calculations using the September 1979 production data log follow:

	<u>Sample Size</u>	<u>Fingerprints/hr</u>	<u>% Rejects</u>
System 1	29	176	6.1
System 2	25	156	5.3
System 3	25	169	3.3
System 4	26	173	5.2
System 5	20	107	9.5

Net weighted average:

$$= \frac{29 \times 176 + 25 \times 156 + 25 \times 169 + 26 \times 173 + 20 \times 107}{125}$$

$$= \frac{5104 + 3900 + 4225 + 4498 + 2140}{125}$$

$$= \frac{19867}{125} = 159 \text{ fingerprints/AFS/hr}$$

Weighted rejects:

$$= \frac{29 \times 6.1 + 25 \times 5.3 + 25 \times 3.3 + 26 \times 5.2 + 20 \times 9.5}{125}$$

$$= \frac{176.9 + 132.5 + 82.5 + 135.2 + 190}{125} = 5.7\%$$

The October, November and December logs give the total number of fingerprint cards attempted per shift for the five AFRSs.

A 5% reject level was used to obtain the net fingerprint cards processed.

Calculations from the October, November and December production data logs give the following:

Total fingerprint cards attempted = 5025

Sample size n = 28

Mean =  $\frac{5025}{28}$  = 179

Rejects = 5%

Net fingerprint cards read:  
179 (1 - 0.05) = 170 fingerprints/AFRS/hr

Combining the September samples with the October, November and December samples yields the following:

$$= \frac{25 \times 159 + 28 \times 170}{53} = 165 \text{ fingerprints/AFRS/hr}$$

## APPENDIX G

### SYSTEM COMPONENT DESCRIPTIONS

#### A. OPERATIONAL COMPONENTS (FUNCTIONS)

##### 1. AUTOCOR (Automated Correspondence)

At this function, all information about a subject (no identification notification, rap sheet, wants, etc.) to be sent to the contributor is accumulated (with fingerprint card, documents, etc. if they are to be returned) and placed into an envelope, addressed, and submitted to the mail room. Responses prepared in AUTORESP on fan-folded computer paper are burst prior to placing in the envelope. No identifications that are to be returned are hand stamped. Incomplete or illegible fingerprint cards are also returned to the contributor from this function.

##### 2. AUTORESP (Automated Response Generation)

This function generates computer-printed responses that will be returned to the contributor. It will, where possible, group responses to the same contributor. The results of the searches in AIDS III and one address label for each envelope (containing multiple responses to a contributor) will be printed on high-speed line printers. These responses are then sent to Automated Correspondence (AUTOCOR). The high-speed printers will also print the name index cards to update the Card Index name files (the manual system).

##### 3. AFRS (Automatic Fingerprint Reader System)

The Automatic Fingerprint Reader System (AFRS), consisting of a card handler, a scanner, a control computer and a data output processor, performs the function of taking the fingerprint image on the fingerprint card and converting it to machine-readable format (Figure G-1).

The fingerprint card is transported from the input hopper via a motor-driven belt and positioned under the scanner. The cards are registered to read the fingerprint image and process control number. The positioning and card movement are computer-controlled. At each position, a pair of fingerprints is scanned. After all pairs are scanned, the card is moved to the output hopper or, if a complete scan was not made, to a reject hopper.

The main components of the scanner of the AFRS provide the light source and the image sensing functions. The light source is a CRT that is computer controlled in its X and Y axes to illuminate the scan pattern. Within the control computer, the following functions are performed: preprocessing scanner movement and illumination control, postediting and encoding of the minutiae detected in the fingerprint images.

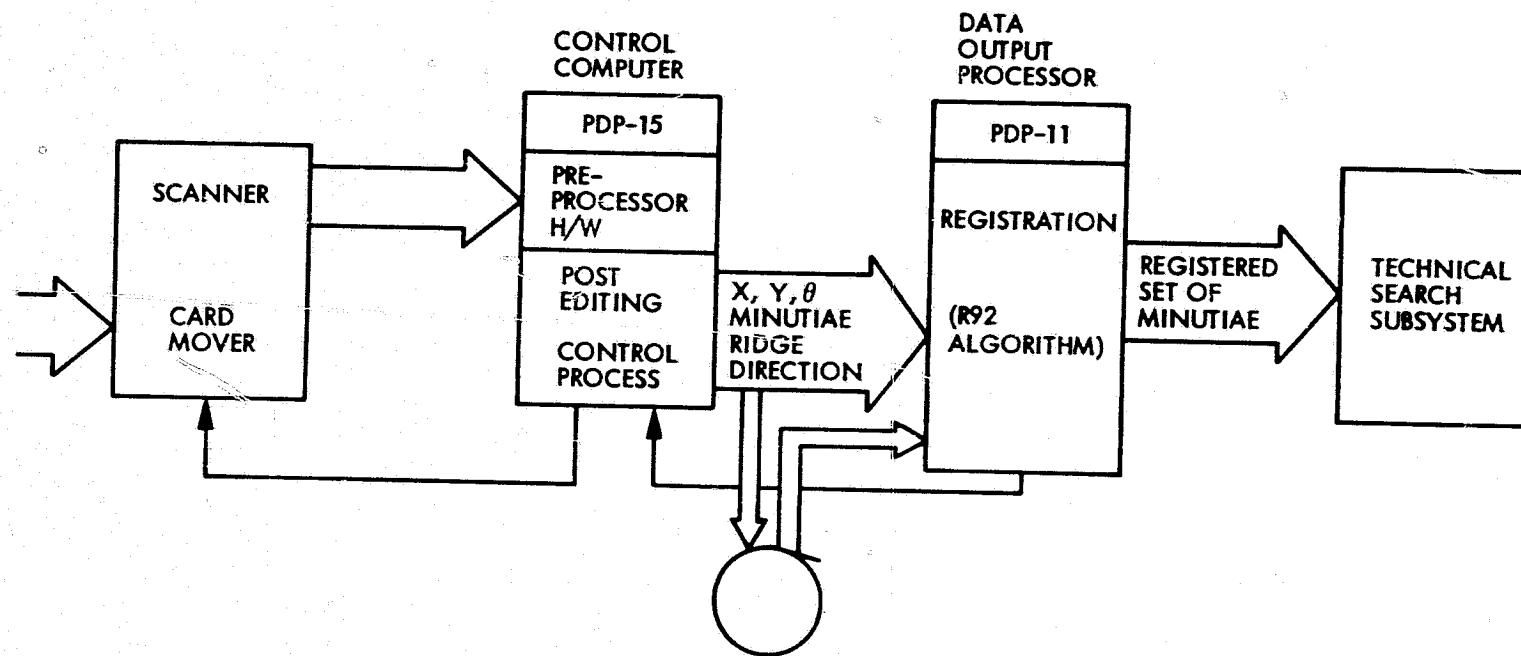


Figure G-1. Automatic Fingerprint Reader System

The AFRS Data Output Processor (DOP) processes the input minutiae information through the registration algorithm. This includes finding the core of the print image, determining the X-Y axes of and referenced to that image, transplanting the X, Y and O minutiae information to the image orientation and reducing the image area to 0.75 in x 0.75 in from the original area of 1.5 in x 1.5 in. This information then constitutes the output of the DOP, and is the registered set of minutiae sent to the matcher. The matcher does the actual comparison of the subject fingerprint data with data in the technical file.

#### 4. BLO (Blocking-Out)

All cards received by BLO are criminal cards without an FBI number. A high level fingerprint classification is performed at this function. Any prints that are illegible are flagged so that the arrest data is not entered at the data entry function (DENT-A and VDENT-A) for the initial subject search.

#### 5. CLASS-A (Classification-A)

The classification process includes determining the NCIC fingerprint classification, writing the classification on the card and entering it into the system via a special purpose terminal. This activity does a full NCIC fingerprint classification on all civil, military, and Coast Guard cards. Reference to the preferred classification is also entered on the card.

#### 6. CLASS-B (Classification-B)

This activity receives all of the criminal cards for which no candidates were found by the automated subject search or, if found, were not identifications. The full NCIC fingerprint classification is determined and written on the card. It is then keyed into the AIDS III system with the use of a special purpose terminal. Reference to the preferred classification is also entered on the card.

#### 7. CLASS-C (Classification-C)

This function classifies all alien registration and personnel identification cards. The classification is made and entered on the card. The classification performed here is not as detailed as required for criminal searching. The cards are then forwarded to the civil file for filing.

#### 8. CLCK (Classification Check)

At this station, the NCIC fingerprint classification verification is made and the cards are sorted into legible and illegible categories. The classification check for civil cards is less extensive than for

criminal cards. A special purpose terminal is used in this function in the verification of the data previously entered into the system.

9. CSORT (Centerline Sort)

The fingerprint cards are inspected to determine the approximate centerline of the inked fingerprints. A template is used to manually determine the centerline of the fingerprints. The cards are placed into one of the ten channels going to the Automatic Fingerprint Reader System (AFRS), depending upon the centerline group to which they belong. Cards for which no centerline can be determined or which are of low print quality are routed directly to the Semi-Automatic Reader System (SAR).

10. DATE STP (Date Stamp)

This manual process handles only alien registration and personal identification cards. The cards are date-stamped and counted. Once a day statistics are logged to the computer. The cards are then classified and forwarded to the civil files. There is no process control number application, subject search, or technical search required for these cards.

11. DENT-A (Data Entry-Cards)

All data from fingerprint cards that is required for the automated subject search and to update the Computerized Criminal Name and Record (CCNR) files is entered by a data entry operator.

Data is entered from the cards to formatted screens selected by the operators. Data is stored in the front-end computer and will be verified by the data-entry verification (VDENT-A) operation. In the DENT-A function, there is no interaction with the host computer. For a detailed description of this function and its relationship to VDENT-A, see Section IX, Paragraph A, Automated Subject Search Performance.

12. DENT-B (Data Entry-Documents)

Within the operation, document information from wants, flashes, expungements, dispositions, etc. is entered into the system. The data entered includes information required to generate a subject search for identification purposes, and the appropriate data to be added/deleted/revised on the individual record (i.e., arrest information, sentencing, etc.). The data is key-entered and stored in a front-end processor (FEP) to await verification (VDENT-B). The process in this component is similar to DENT-A.

13. ENC (Encode Input Data-Cards)

In this function, the data input formats are checked and the criminal arrest data are encoded. The operator checks the charges on the subject fingerprint card against a list of standard charges, selects the most appropriate representation and enters that code number on the card.

14. ENCDOC (Encode Input Data-Documents)

All dispositions and miscellaneous documents which generate inquiries or updates against the master file are coded at this function. Many documents require that the coding be on forms which accompany the source document. Examples of items coded include offenses, date of birth, race, sex, etc.

15. ENCK (Encode Check-Cards)

This function is an independent validation of the charge codes selected by the ENC operation. The operator compares the charge code on the fingerprint card against a set of standard charges to ensure that the proper code has been selected. The cards are then sorted and routed to the appropriate function downstream.

16. ENDOCK (Encode Check-Documents)

The encoding performed in function ENCDOC is reviewed and verified at this operation.

17. FLAB (Film Processing and Fiche Duplication)

The Film Processing Lab receives 16mm cartridge film containing 1000 card images/cartridges from the Image Capture (MFLIM) stations. It develops the film, then produces and duplicates ultramicrofiche at a 10X reduction (containing 2000 card images/fiche).

18. FLOAD (Film Load)

This function is not a work station per se, but an activity. The duplicated microfiche are distributed to each of the Image Comparison (ICI) and Verification (ICV) work stations for insertion in the appropriate location in the microfiche carousels.

19. ICI (Image Comparison Identification)

The function of the Image Comparison Identification component is to display fingerprint images for the examiners to compare subject prints against candidates selected as a result of either a subject



search or a technical (fingerprint) search. The examiner must determine whether a positive fingerprint match has been made.

The search inquiries are assigned to stations based on the inquiry NCIC fingerprint classification of the particular candidates. Each station contains microfiche fingerprint images of both the inquiry subject and the candidate(s) selected from the fingerprint microfiche master file. The inquiry and the candidate fingerprint images are automatically displayed side-by-side. A keyboard accepts comparison decisions and control commands from the examiner. A separate text display prompts the operator and displays system status.

The microfiche fingerprint card images at each work station are stored in carousel-type storage and retrieval mechanism. Each station contains 500 fiche, and each fiche contains 2000 images, giving a total capacity of 2,000,000 images per station.

#### 20. ICV (Image Comparison Verification)

The Image Comparison Verification function verifies the identification (if any) made in the Image Comparison Identification (ICI) function. The process and work station facility is similar to the ICI function. ICV has a smaller workload than ICI because it only verifies the ICI identifications.

#### 21. MAIL (Mail Room)

Mail is received daily from the post office. The input volume is highly variable (from 17 cubic feet to 68 cubic feet per day). The mail is opened and sorted into three basic categories:

1. Fingerprint cards (both civil and criminal).
2. Alien registration and personal identification fingerprint cards.
3. Dispositions, flashes, wants, expungements, etc.

It then is routed to the next appropriate function.

#### 22. MFILM (Image Capture Microfilm)

At the Image Capture function, fingerprint cards are microfilmed at a 6.3X reduction. The associated PCN are read with an optical character reader (OCR) and associated with the image in the Transaction Record. 1000 card images are produced on each 16mm microfilm cartridge.

### 23. PCN (Process Control Number Application-Cards)

A process control number (PCN), which is a unique, machine-readable number, is printed on each inquiry fingerprint card as it enters the system. The PCN is a 12-digit number structured as YYDDSSSSSCC where:

YY = digits of year

DDD = Julian date

SSSSS = Five digit sequence number

CC = check digits

As each PCN is generated, a Master Transaction Record (MTR) is established. The MTR is the means by which the AIDS III System can track the detailed status of each inquiry card from the time it enters the system until it is disposed of at the end of the processing cycle. The MTR consists of a series of fields which provide the means of defining the detailed status of each card.

### 24. PCN APPL (Process Control Number Application-Documents)

All documents processed by the AIDS III system require a unique process control number (PCN) which is stamped on the document (or an attached routing form) via a "Bates" type stamp machine.

### 25. QC (Quality Check)

At this manual function, the fingerprint cards are checked for completeness of information. Any incomplete or inappropriate cards are returned to the contributor. Several hand stamping operations are used to highlight special conditions.

### 26. QUERY (On-Line Query)

To accommodate special requests from contributors and FBI offices received over the telephone, via wires or from special correspondence, one CRT work station is designated for on-line interrogation of the AIDS III files. Most requests will be satisfied by reading information from the CRT screen at the work station. Some requests will require data to be printed out from individual file records on the Computerized Criminal Name and Record (CCNR) files and sent to the requestor. Interfacing with the manual system for fingerprint cards, jackets, or photographs may be required.

27. READ (Quality Control, Check, Read and Annotate-Documents)

At this point, all documents and final dispositions are mixed together. The dispositions are separated and sent on to the next operation for coding. All remaining documents are given a quality control check to ensure that information required for data entry is correct. Documents found to be incomplete are sent back to the contributor or to the manual system.

28. SAR (Semi-Automatic Reader)

Cards that have one or more fingerprints rejected by the Automatic Fingerprint Reader System (AFRS) require manual minutiae encoding using the SAR. Fingerprints that cannot be manually encoded are designated as rejects and returned to the contributor.

To encode the minutiae data manually, the PCN is keyed into the system, and the finger number to be encoded is displayed on the screen. That particular fingerprint is then placed under a high resolution closed circuit television (one finger at a time). The print is registered (squared-up and centered), and a trackball used to position a cursor on the CRT screen. The point is registered with a button and the cursor is then moved 1/4 to 1/2 in. (usually along a line of a fingerprint and showing up as a darker line), then registered a second time. This creates a short line. Using the center, x and y coordinates, an angle is calculated. Once a sufficient number of minutiae are encoded (usually 40 to 100 individual points) the data is registered and then sorted on Y descending order. This data is then transferred to the candidate minutiae file to complete the information necessary for an automated technical (fingerprint) search.

29. SEAR (Search Review)

In those cases where an identification has been made and verified (ICI and ICV), this function authorizes the update of the arrest data to the files. Where no positive identification has been made, this function reviews the parameters used in the search. The search parameters and statistics are displayed for the inquiry and if, in the judgement of the SEAR operator, changes to one or more of these parameters could bias the search process such that a new candidate or candidates may be located, the operator may cause a new search to begin at any one of several steps. For new criminal file additions, the SEAR operator assigns a unique FBI number to the card, updates the Transaction Record and routes the card back to be microfilmed (MFLIM) for permanent addition to the file.

The search review operator also controls the secondary card routing (i.e., non-identifications are routed to the proper function to continue their flow through the system). Inquiry into the Master Transaction Record provides the operator with the necessary information to route the card.

### 30. VDENT-A (Verify Entry-Cards)

The VDENT-A function verifies the fingerprint card data that has been entered by the data entry operator (DENT-A). The data parameters required for the automated subject search are entered first. When this data (60-80 characters) has been verified, the automated subject search is initiated. While the search proceeds, the VDENT-A operator enters the remaining arrest data (average of 80-100 characters). The search process is discussed in Section IX, Paragraph A, Automated Subject Search Performance.

Based on the results of the subject search, a message is displayed instructing the VDENT-A operator where to route the fingerprint card. If there are one or more candidates, the card is sent to Search Review (SEAR); if there are no candidates, but it is a military card, it goes to the Civil file. Non-candidate criminal cards are routed to be classified in more detail (CLASS-B), and non-candidate civil cards are routed to have a classification check (CLCK) prior to being submitted for an automated technical (fingerprint) search. The search and arrest data, along with the search results, are stored in the Transaction Record (TR) file to await final disposition.

### 31. VDENT-B (Verify Data Entry-Documents)

At this component, document information entered in data entry (DENT-B) is verified. After the descriptive data required for the subject is entered, the automated subject search is initiated. As the search is being conducted, the operator enters the remaining descriptive data for verification. The VDENT-B operator is notified by the system if an identification has been made, and routes the document accordingly.

### 32. WAND (Wand Out of System)

This function receives from quality check (QC) any rejects or incomplete fingerprint cards that are to be removed from the AIDS III system. A card may be rejected by QC for the following reasons:

- (1) Only four fingers were fingerprinted.
- (2) Information is missing.
- (3) Search not required by law for the applicant card.
- (4) A non-AIDS FBI number.
- (5) Civil file name search required.

The PCN number is read by an optical character recognition (OCR) wand, and the appropriate reason for removal of the card from the system is entered into the system via a keyboard terminal. The cards are then routed to either the manual system or automated correspondence (AUTOCOR).

## B. COMPUTER SUBSYSTEMS

### 1. DEDS (Data Entry and Display Subsystem)

(1) Description: The Data Entry and Display Subsystem consists of a series of free-standing computers used to enter, validate, and buffer data prior to burst transmission to the System Supervisor. Information can also be returned and displayed on some of the DEDS equipment (i.e., the results of a subject search are returned to a VDENT operator with routing instructions). The Data Entry and Display Subsystems support the basic data entry, verification and inquiry functions.

(2) Configuration: The SEAR, WAND, and Classification functions (CLASS A and B and CLCK) are all configured with their own front-end processors (FEPs). One FEP is planned to handle the SEAR and WAND functions, with a second used as backup. Three sets of FEPs are planned to handle the classification and classification check functions (CLASS A and B, and CLCK). Each set consists of a primary and a backup FEP. The entry and verification (DENT-A and B, and VDENT-A and B) portion of the DEDS consists of 9 separate FEPs (Four Phase Equipment), each hooked directly to the System Supervisor. There is no backup for this equipment (that is, there is no auxiliary FEP to switch to in the event of a failure).

(3) Interfaces: The main components of DEDS and its associated actions and interactions with the System Supervisor are as follows:

#### a. Data Entry and Verification

Enter data for subject search from card and verify.

Send verified data to System Supervisor for subject search.

Enter, verify, and transmit arrest data for criminal cards.

Enter, verify and transmit file update information for documents.

Receive card routing information.

#### Response by System Supervisor

Update Master Transaction Record (MTR).

Update Transaction Record (TR) with subject search information.

Initiate subject search.

Update MTR with search results.

Send card routing information to VDENT-A or B.

Format Image Comparison Request (ICRQ) and send to Image Comparison Subsystem (ICS).

Receive and send additional criminal card data to Subject Search and Report Generation Subsystem (SSRG) for TR update.

Forward file update requests and information to SSRG document.

b. Classification

Enter and verify full NCIC fingerprint classification.

Response by System Supervisor

Update MTR.

Send classification to Technical Search Subsystems (TSS) for TR update.

Remove illegibles from the system.

c. Wand Out of System

Transmit process control number and reason data on those cards being removed from the AIDS III system.

Response by System Supervisor

Update MTR.

Close MTR for rejected cards.

d. Search Review

Request status information by Process Control Number.

Change search parameters and initiate a new search.

Remove cards from system.

Route cards according to search status.

Assign new FBI number for criminal non-identifications (non-idents).

e. Response by System Supervisor

Send search status information from SSRG.

Close MTR for cards being removed from system.

Update MTR, TR, and search parameters for a new search.

Authorize updates or additions to the Computerized Criminal Name and Record (CCNR) files and the Minutiae Master File (MMF) as appropriate.

Authorize a response generation.

2. ICS (Image Comparison Subsystem)

- (1) Description: The function of this subsystem is to compare current subject prints against candidate prints (both sets of prints are on microfiche and are displayed automatically).

As a result of a subject or technical (fingerprint) search, a list of one or more candidates may be generated. The image comparison functions (ICI and ICV) compare the fingerprints on the current subject against the fingerprints of the candidates on the list. A simple ident or non-ident response for each candidate is given.

For rush requests, the FBI number can be entered at an image comparison terminal and the fingerprint location will be found. The microfiched print is then displayed and compared with the inquiry hard copy fingerprint card. No response to the System Supervisor is entered.

- (2) Configuration: For the ICS, all of the image comparison consoles are hooked into a single front-end processor (FEP). One FEP is expected to handle the processing requirements of the subsystem, although a second FEP for backup is provided. These two FEPs are joined by switchable controllers.

- (3) Interfaces: The main components of the ICS and its associated interactions with the System Supervisor are as follows:

a. Image Comparison Consoles

Request fiche location by FBI number (for rushes).

Receive image comparison request and send microfiche retrieval information to the microfiche file hardware.

Transmit image comparison results.

b. Response by System Supervisor

Form and send image comparison requests using PCN and FBI number with fiche locations.

Receive image comparison results.

Update MTR with search results.

3. PICS (Process Control Number and Image Capture Subsystem)

(1) Description: The PICS subsystem is primarily a message handling function. The information collected, Process Control Number (PCN) and microfilm location are buffered and then sent to the System Supervisor. For each fingerprint card that enters the AIDS III, a PCN is assigned. This number is used to track the card and access any pertinent information. The fingerprint cards are microfilmed and then microfiched with the appropriate location information appended to the Transaction Record (TR).

(2) Configuration: In the PICS subsystem, the PCN machines, microfilm cameras and the microfiche composers are all hooked into a single front-end processor (FEP). One FEP is planned to handle the processing requirements of the subsystem, but a second FEP is provided for backup. These two are jointed by switchable controllers. The facility sensors are tied directly to the System Supervisor and do not interface with the PIC subsystem FEPs.

(3) Interfaces: The main components of the PICS subsystem and its associated actions and interactions with the System Supervisor are as follows:

a. PCN Machines

Transmit last valid PCNs.

Transmit invalid PCNs.

Actions by System Supervisor

Create MTR and TR for each PCN.



b. Image Capture Cameras

Transmit PCN, frame no., type (permanent, current, temporary), and roll no.

Response by System Supervisor

Update MTR.

Update TR to show location on microfilm.

c. Microfiche Composer

Transmit PCN, fiche no., type, frame no.

Response by System Supervisor

Update MTR.

Update TR to show location on microfiche.

Based on fingerprint classification, calculate which ICI and ICV consoles the permanent microfiche should be routed to.

4. SS (System Supervisor)

- (1) Description: The System Supervisor is comprised of three main functions: system monitoring and control, system simulation and management report generation. The latter two are discussed separately in paragraph 4. The main function discussed here is that of system control and monitoring. The handling and routing of information is the major effort involved in this portion of the System Supervisor.

Each of the subsystems, and their associated components, transmit information to the System Supervisor. Part of the information is kept by the System Supervisor while other parts of the information are routed to other subsystems. Some of the information requires manipulation and a response to one or more subsystems. Myriad combinations of data routing can occur, making the overall interaction very complex.

The main functions handled by the System Supervisor are:

Monitors, controls, and interacts with all of the related subsystems and with the card allocator system.

Maintains responsibility for card routing and process control.

Acts as link between all subsystems.

Controls the Management Reports and System Simulator.

Creates, updates and closes Master Transaction Record (MTR).

Purges all references to a PCN for a closed MTR.

Creates, updates, purges a Transaction Record (TR).

Controls and authorizes response generation.

Controls file updates and authorizes updates of specific files (CCNR, MMF, etc.).

Polls various systems for information.

Maintains Equipment Status files.

In addition, each subsystem, computer and component will have monitoring devices connected in some undefined fashion. These devices can range from very simple (an empty hopper indicator) to very complex (switchover to a backup unit due to impending failure). A brief list of capabilities and/or functions is as follows:

Equipment Status - i.e., sensors linking a component and its subsystem computer - may relate operational status, queue sizes, etc.

Operating Limits - i.e., overload or underload condition.

Measurement Data - inputs to count workloads, queue sizes, response times, etc. for both a subsystem and/or individual station (especially as relates to deflectors and allocators).

Diagnostics for failures, including:

Automatic switchover to backup functions.

On-line fault isolation diagnostics.

Fault isolation for non-standard devices.

- (2) Configuration: For the System Supervisor, one CPU is planned to handle the processing requirements, with a second planned for backup. The two CPUs are joined by switchable controllers. The system management terminals, management reporting facilities, and program development facilities are also tied into the System Supervisor CPUs.

(3) Interfaces: Interfaces with each of the subsystems as detailed in the description of the respective subsystem.

(4) Management Report Generation and System Simulation (MRGSS) Task

- a. Description: The MRGSS task is part of the System Supervisor. Different files (hardware status, PCNs, manpower, etc.) are accessed and the information contained within these files is used to create Management Reports. There is no definition as to the content or frequency of these reports, therefore, no specific rates or information transferrals can be implied. The real-time interactive nature of monitoring suggests a very detailed set of informational files. This set of files is proposed to provide a mechanism for data collections, report generation and system performance monitoring.

A software simulator which models the system operation is proposed for predicting volumes, queues, etc., given variations in card mixtures, missing components, or other dynamic portions of the system. This simulation is inclusive down to the component level (i.e., the effect of removing a single component or station from operation can be evaluated). The simulator package will have access to many of the same files utilized by the management report task. This feature of the System Supervisor is only generally addressed at the highest conceptual level.

- b. Configuration: This task is a part of the System Supervisor and the combined configuration is addressed in the configuration discussion, above.

- c. Interface:

Management Report System Simulator Task

Real-time interactive monitoring of stations

Real-time monitoring of hardware availability

Receive inputs from System Supervisor reflecting:

Hardware status

Manpower configuration

Queue lengths

Productivity of individual stations

Card mix and routing

Accumulate data and generating reports

Interactive System Simulator

Responses by System Supervisor

Send status of any part of the system

Send rates for an individual station or a set of stations on demand

Send diagnostic data and keep the information files updated

5. (SSRG) (Subject Search and Response Generation Subsystem)

- (1) Description: The System Supervisor formulates a search request and sends it to the SSRG subsystem. After a search of the Computerized Criminal Name (CCN) file, a list of candidates (if any) is returned to System Supervisor, which routes the name of a candidate(s) to the data entry verify operator (VDENT-A and B) with a response from search review (SEAR).

A positive ident from the Image Comparison verification function (ICV) results in an authorization to update the CCNR files. Responses are generated, and those that require return of the original cards are matched with their responses and sent to the mail room.

The SSRG subsystem also maintains the information about the inquiry subject in the Transaction Record (TR). This information is compiled and then used in the updating or creating of records in the Computerized Criminal Name and Record (CCNR) files.

- (2) Configuration: The SSRG subsystem, consists of response generation line printers, and an estimated 3 or 4 Subject Search Modules (SSMs). The SSMs are envisioned to be computers with any 3 of the 4 able to handle the load. The extra is a backup in case of failure or some other form of system degradation.

The SSRG architecture calls for two CPUs. Under normal operations, the two are to operate in a load sharing mode (i.e., the prime CPU controls the search and file update processes while the secondary CPU handles the response generation process). The CCNR files are shared between the two CPUs.

If one of the CPUs is down, the prime function subject search will presumably be executed in the up machine, with response generation occurring as time allows.

(3) Interfaces:

a. SSRG Computer

Receive Subject Search Request

Return list of candidates (if any)

Receive arrest record for criminal cards

Store data for probable file update in the TR

Store data with new FBI number if non-ident in the TR

Update CCNR files from data in the TR when authorized by SEAR

Generate responses

b. Responses by the System Supervisor

Format Subject Search request and send to SSRG

Update MTR with search results

Obtain microfiche location for Subject Search Candidate list

Send card routing information to the VDENT function

Send Response Generation Authorizations

Send CCNR Update Authorizations

6. TSS (Technical Search Subsystem)

- (1) Description: This subsystem attempts to match the inquiry subject fingerprints with a set of Minutiae Master File (MMF) fingerprints. Additional data similar to the subject search data plus the NCIC fingerprint classification is used in the technical search process. This subsystem automatically reads the fingerprints, extracts minutiae data, and seeks a possible match. The Automatic Fingerprint Reader System (AFRS) and Semi-Automatic Readers (SAR) are used to "read" the fingerprint and calculate minutiae data. The minutiae data are compared against the MMF data (by NCIC classification bins) in the Search Processor Modules (SPM) to obtain the most likely candidate.

(2) Configuration: For the TSS, all of the Search Processor Modules (SPM - estimated at 5 to 15), all 5 of the AFRS, and the FEPs for the SARs are hooked directly to the subsystem computers. One CPU is planned to handle the load, but a second CPU is proposed as a backup. These two are joined by switchable controllers.

(3) Interfaces: The main components of the TSS and the associated interactions with the System Supervisor are as follows:

a. TSS Computers

Receive full NCIC fingerprint classification (plus references) and search data

Transmit results of search including list of candidates (if any)

Transmit search statistics (parameters) to SEAR

Receive authorization for updates or additions to Minutiae Master File (MMF)

b. SPMs

Receive data required to perform technical (fingerprint) search

Send search results to TSS

c. Response by System Supervisor

Send full NCIC fingerprint classifications (plus references) and subject data

Receive search results

Send search results

Update MTR

Form Image Comparison Request

Send search statistics to SEAR

Send authorization for updates or additions to MMF

## C. TRANSACTION FILES

### (1) MTR (Master Transaction Record)

The data record contains tracking data on each fingerprint card and its related microfilm image as it flows through the AIDS III System. The record is maintained by process control number (PCN) in a file associated with the System Supervisor. The basic activity against the record is that, whenever a fingerprint card (identified by a PCN) is processed by a function with a computer interface, notification of that fact is transmitted to the MTR. This audit trail is effective in identifying cards in the system over a specified length of time and by the last automated function in which the card had been processed. Sixty-four bits of storage are proposed. Other data contained in the MTR includes: card type and priority, identification status, card disposition, and file maintenance status.

### (2) TR (Transaction Record)

Although not fully defined, the TR is used to contain subject and arrest information that is stored temporarily (i.e., the information that will ultimately be used for updating an existing record or creating a new record on the Criminal Name and Criminal Record files). Various steps through the process add data to the Transaction Record. Both the technical and subject searches use the information contained in the TR. Information contained in the TR includes PCN, microfilm location, microfiche location, subject search information, arrest and any additional information, NCIC fingerprint classification and references, and the FBI number.

## APPENDIX H

### STUDY RESULTS OF AFRS AND PCN AVAILABILITY

#### A. AUTOMATIC FINGERPRINT READER SYSTEM (AFRS)

An analysis of FBI maintenance logs for the Automatic Fingerprint Reader System (AFRS) currently being used in the fingerprint card file conversion and the Automated Technical Search Pilot Study was made. The basis for this analysis was the Technical Maintenance Unit Processing Section System (maintenance) Logs for all five AFRSs for the period June 1979 through December 1979. These logs covered unplanned maintenance (operation code 72), a few planned maintenance records (operation code 71), repairs, operation/service codes, assembly involved, and a description of the problem and correction. Table H-1 reflects the results of the analysis of the unplanned maintenance of the five AFRSs. (Preventive maintenance data is not included in the table).

Table H-1. AFRS Availability Including Processors

System Number	Maintenance Period In Weeks	Service Number Repairs	MTTR In Hours (Note 1)	Response Time In Hours (Note 2)	MTBF In Hours (Note 3)	Unit Availability (Note 4)
1	27	26	0.61	1.0	140.2	0.9886
2	21	31	0.84	1.0	91.5	0.9803
3	25	45	1.74	1.0	75.0	0.9648
4	25	31	0.72	1.0	108.9	0.9845
5	22	25	1.07	1.0	118.8	0.9829
Average			1.00	1.0	106.9	0.9816

**Notes:**

1. Mean Time to Repair - actual service time in hours, excluding travel.
2. Period of time from machine failure to start of repair work (based on Rockwell response time estimates as stated in Reference 5).
3. Mean Time Between Failures =  $\frac{135 \text{ hr/week} \times \text{Maintenance Period}}{\text{Number of Service Repairs}}$



$$4. \quad \text{Unit availability} = \frac{\text{MTBF}}{\text{MTTR} + \text{Response Time} + \text{MTBF}}$$

The availability for the AFRSs (including processors) derived in Table H-1 is 0.9886, which is somewhat better than the availability of 0.9500 indicated by Rockwell in Reference 24, page 6.

The following is a tabulation of the maintenance information for the AFRSs excluding the processors.

Table H-2. AFRS Availability Not Including Processor

System Number	Maintenance Period In Weeks	Service Number Repairs	MTTR In Hours (Note 1)	Response Time In Hours (Note 2)	MTBF In Hours (Note 3)	Unit Availability (Note 4)
1	27	19	0.76	1.0	191.84	0.9909
2	21	22	0.74	1.0	128.86	0.9867
3	25	37	1.21	1.0	91.22	0.9763
4	25	28	0.76	1.0	120.54	0.9856
5	22	17	0.78	1.0	174.71	0.9899
Average			0.85	1.0	141.43	0.9883

Notes:

1. Mean-Time-to-Repair - total service time in hours, excluding travel.
2. Period of time from machine failure to start of repair work.
3. Mean-Time-Between-Failures =  $\frac{135 \text{ hr/week} \times \text{Maintenance Period}}{\text{Number of Service Repairs}}$
4. Unit availability =  $\frac{\text{MTBF}}{\text{MTTR} + \text{Response Time} + \text{MTBF}}$

Table H-2 gives an overall MTBF of 141.43 hours, which is considerably less than Rockwell's 700 hours (Reference 24, page 6). The FBI log MTTR (0.85 hours), plus the Rockwell estimated response time (1.0 hr) equals 1.85 hours which is shorter than Rockwell's estimated 4.0 hours (3.0 hours, given in Reference 24, page 6, plus the estimated 1-hour response time from Reference 5, page 47).

The empirical JPL data was used in the development of the simulation model. It was felt that this data reflected a more realistic view of actual conditions. A concern of AFRS availability is the potential decreasing MTBFs and increasing MTTRs as the equipment ages. No experience was presented which would assist in this projection.

#### B. PROCESS CONTROL NUMBER (PCN) MACHINES

An analysis of FBI maintenance logs was made for the period September 1978 through April 1979. Table H-3 reflects the results of this analysis. The average MTBF for the PCN machines during this period was 126.14 hours. This compares to 168 hours stated by Rockwell (Reference 24, page 6). The average Mean-Time-To-Restore from the FBI log is 3.39 hours as compared to the Rockwell Mean-Time-To-Restore of 1.6 hours plus (a repair time of 0.6 hours, and an estimated 1 hour response time).

Using the Rockwell numbers, the average availability for the PCN machines was 0.9906 whereas based on JPL study information, the average was 0.9738. This difference did not seem to have a significant effect on the system availability unless a prolonged failure occurred. This component had the lowest availability factor and, if the two machines proved to be unreliable, a significant queue could build up at this point.

The empirical JPL data was used in the development of the simulation model. It was felt that this data reflected a more realistic view of actual conditions. A concern of PCN availability was the potential decreasing MTBFs and increasing MTTRs as the equipment ages. No experience was presented which would assist in this projection.

Table H-3 PCN Printer Availability

PCN Systems	Mean-Time To-Repair In Hours (Note 1)	Response Time In Hours (Note 2)	MTBF In Hours (Note 3)	Availability (Note 4)
1	3.70	1.0	158.82	0.9713
2	1.08	1.0	93.46	0.9782
Average	2.39	1.0	126.14	0.9738

Notes:

1. Total-Service-Time in Hours, excluding travel.
2. Period of time from machine failure to start of repair work.
3. Mean-Time-Between-Failures =  $\frac{135 \text{ hr/week} \times \text{Maintenance Period}}{\text{Number of Service Repairs}}$
4. Unit availability =  $\frac{\text{MTBF}}{\text{Repair Time} + \text{Response Time} + \text{MTBF}}$

## APPENDIX I

### DISCREPANCIES BETWEEN WORK LOAD VALUES

Figure I-1 shows the Design Work Loads for the AIDS III processing functions in which the work flow is measured in cards/day. In Figure 2, all figures have been converted to cards/hour during the day shift, using the formula:

$$\text{cards/hour (day shift)} = \frac{2}{3} \times \frac{1}{7.5} \text{ cards/day}$$

to provide for the 2:1 ratio of the day shift over the night shift.

The Rockwell AIDS III Operating Concept Chart displays a view of the system in terms of cards/hour, based upon the Design work loads in Figures I-1 and I-2. Using the work load information provided in the Operating Concept Chart, Figure I-3 was drawn. It was found that there are certain discrepancies between the two sets of numbers.

In order to analyze the meaning of these discrepancies, Table I-1 was created. It lists the percentage values at which the workflow splits at selected nodes in the system. These nodes correspond to nodes used for the computer simulation studies that were conducted for the AIDS III Evaluation Report. The model is shown in Figures 4 and 5, where the selected nodes are identified as NODE 1, NODE 2 and NODE 3. The Table also includes information on other percentage values of special significance.

The two percentage numbers given for each item in the Table correspond to values calculated according to the information provided in the Design Guidelines of the Identification Division of the FBI and the Operating Concept Chart of Rockwell, respectively.

The disagreements between the two sets of numbers can be seen by observing Figures I-2 and I-3. Most of the differences are small and probably of little significance, except for the fact that they do exist. After examining Figures I-2 and I-3 and Table I-1, a few observations can be made:

- (1) In the Design Guidelines, 52% of the total number of cards that go to Subject Search (SS) are criminal cards, compared to 49.56% in the Operating Concept Chart (Table I-1).

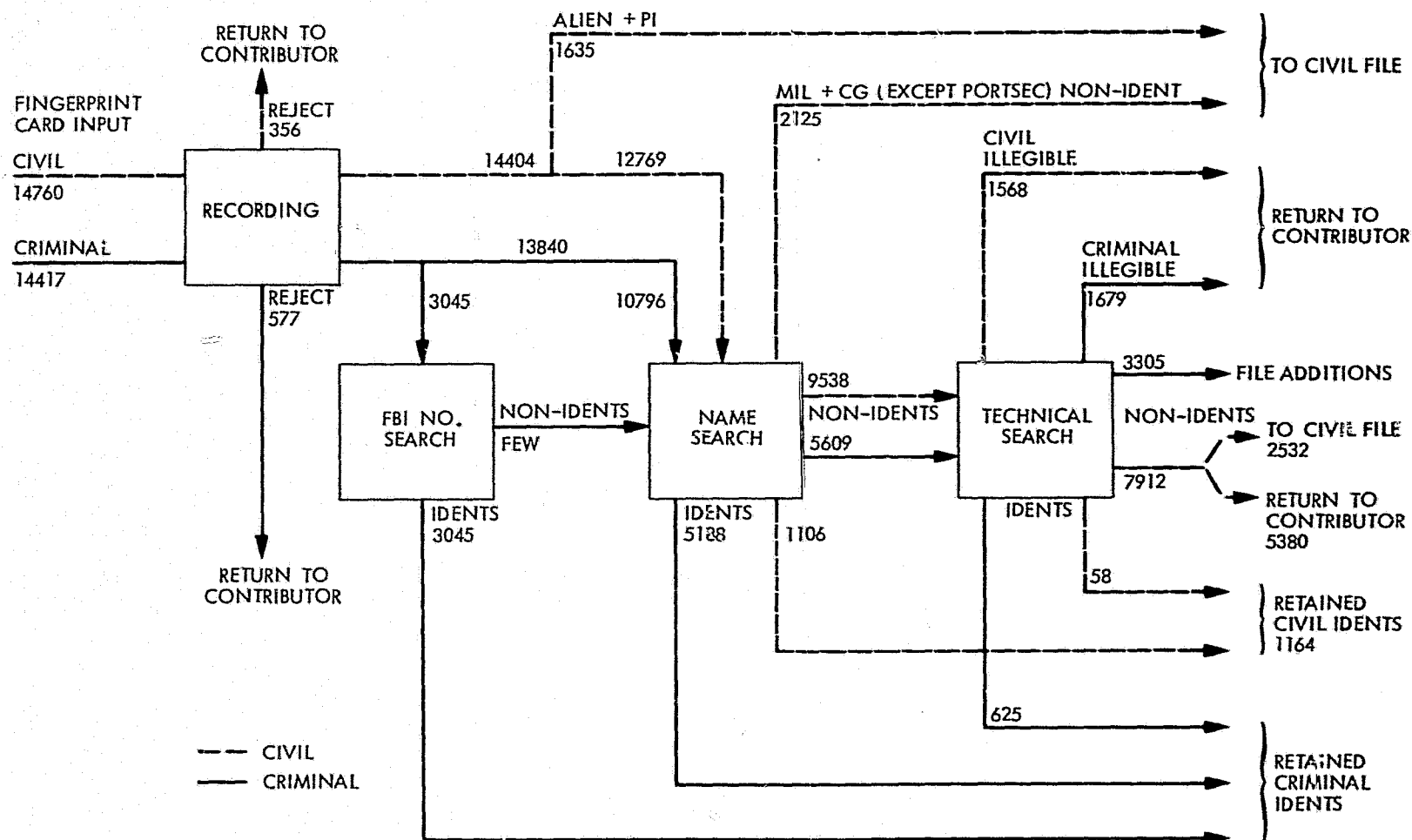


Figure I-1. Design Guidelines Work Loads - Cards/Day

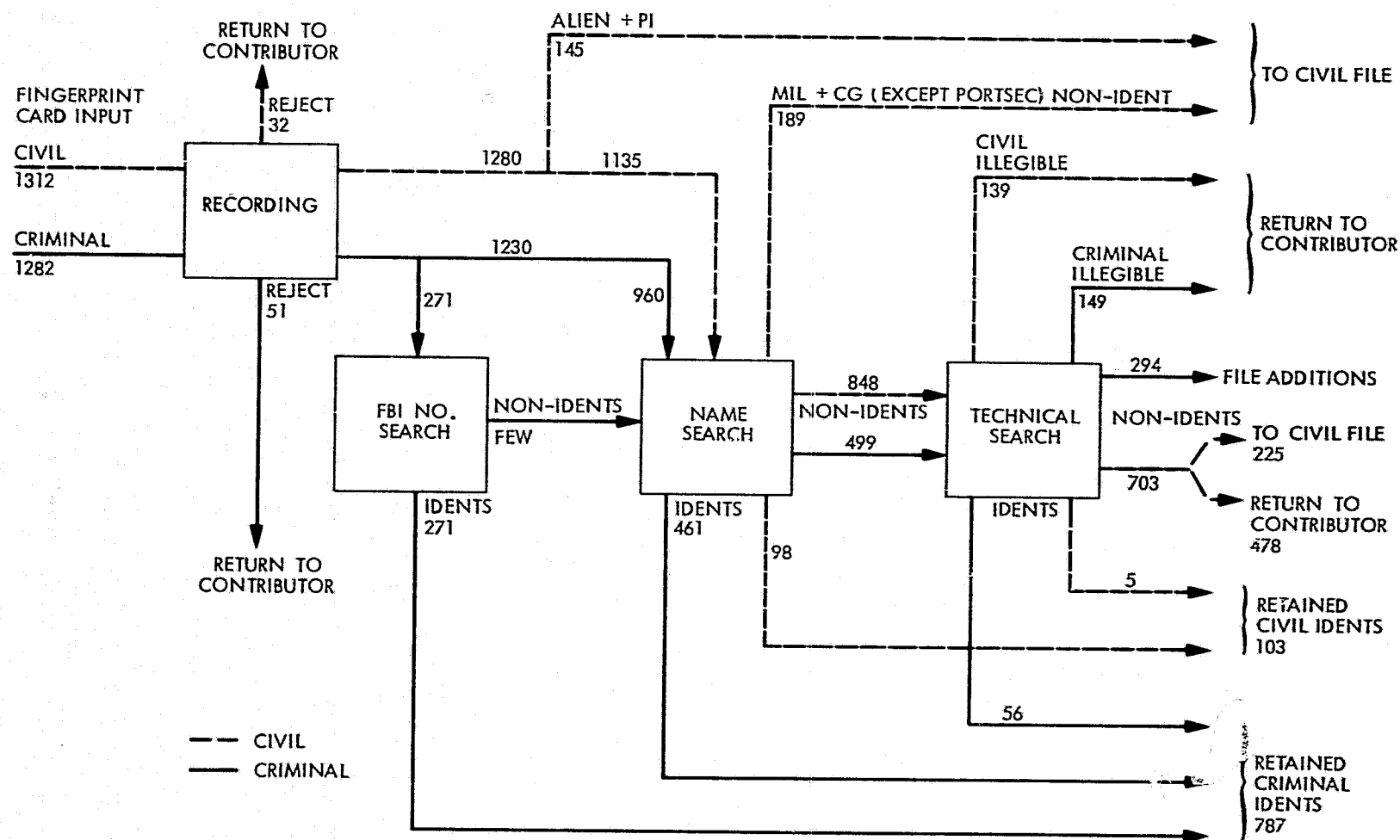


Figure I-2. Design Guidelines Work Loads - Cards/Hour (Day Shift)

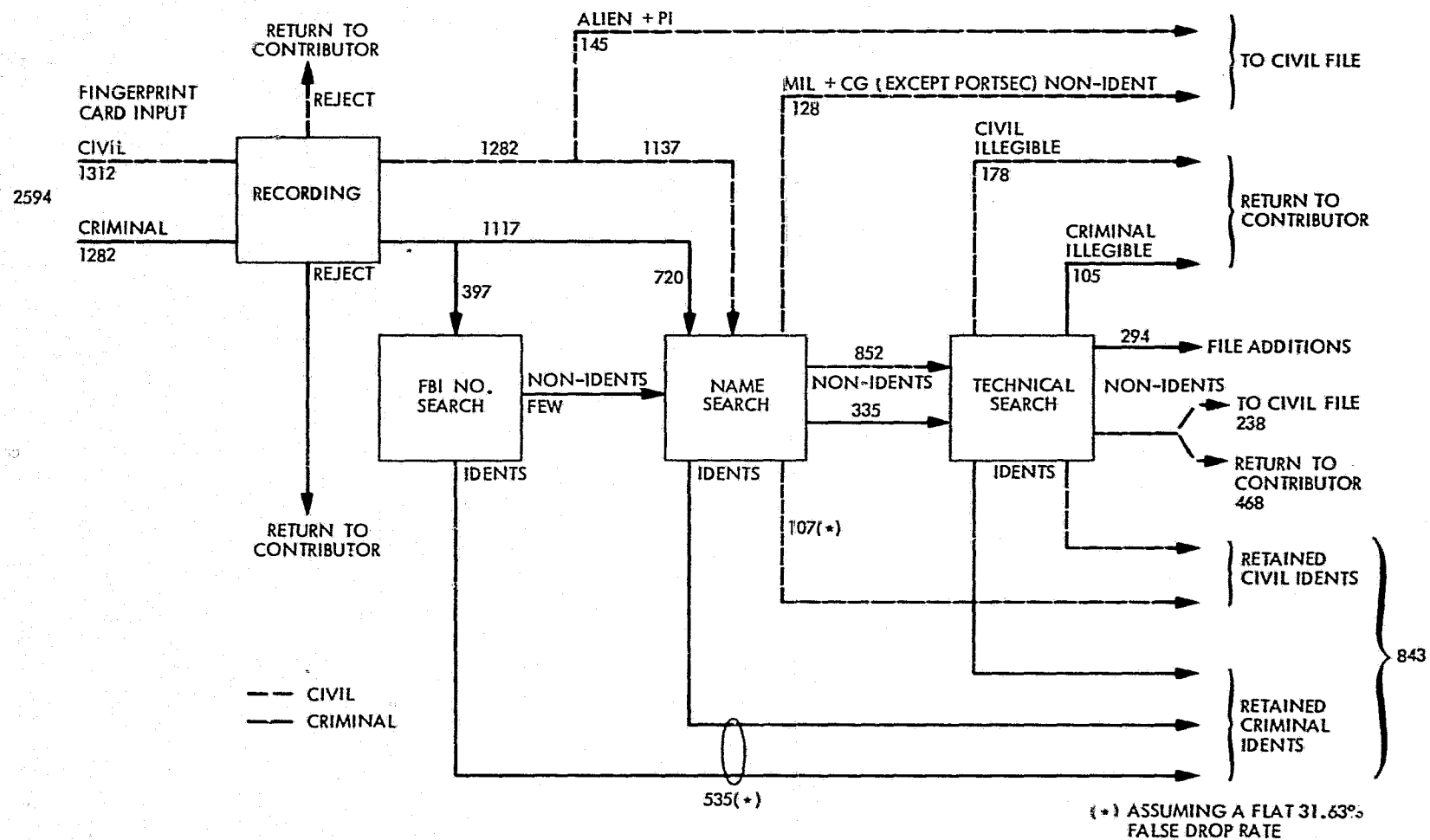


Figure I-3. Operating Concept Chart Work Loads - Cards/Hour (Day Shift)

- (2) The percentage of cards with FBI numbers (both as a fraction of the total number of cards, and as a fraction of the total number of criminal cards) is significantly higher in the Operating Concept Chart (11.44% against 18% and 22% against 35.54%, respectively). This differential should result in a higher success rate by the Subject Search function, with off-loading of the Technical Search Function as a consequence. This is confirmed by the percentages of cards with unverified SS candidates of 35.08% (FBI) against 42% (Rockwell). However, the total number of cards identified by the system is equal in both cases (37%), and the percentage of Criminal Cards with verified SS candidates is 59.49% (FBI) against 47.87% (Rockwell), which seems contradictory. The most likely reason for the apparent contradiction is that the Design Guidelines contain information only on verified identifications. On the other hand, the Operating Concept Chart shows information on unverified identifications, and gives an overall false drop rate after the Image Comparison (Verification) function has been completed. This makes comparison between figures in both charts difficult. The figure of 47.87% was calculated using the 31.63% false drop rate as the Table indicates which, in this case, was probably not a very accurate approximation. The false drop rate will vary depending on the card type even though, overall, it will stay approximately at the 31.63% level.
- (3) From Table I-1, the percentage of cards with verified Technical Search identifications and no SS candidates is 5.74% (FBI) against 19.49% (Rockwell). However, the figure of 19.49% was calculated using the already mentioned false drop rate of 31.63%, which might not be accurate for this card type.

In the Rockwell chart, an alternative to calculating the number of TS identifications is to apply the TS success rates for civil and criminal cards as deduced from the Design Guidelines. Using Figure I-1:

The probability of finding TS candidates for civil cards, given that no candidates were found in SS:

$$\frac{58}{9538-1568} \times 100 = 0.7\%$$

The probability of finding TS candidates for criminal cards, given that no candidates were found in SS:

$$\frac{625}{5609-1679} \times 100 = 15.9\%$$



TABLE I-1

	Identification Division Design Guidelines	Rockwell Operating Concept Chart
<u>NODE 1</u>		
Full Classification (Civil & Military)	47.99%	50%
Blocking-out (Criminal w/o FBI #)	40.57%	32%
With FBI #	11.44%	18%
<u>NODE 2</u>		
Criminal w/o Candidates	21.08%	15%
Civil w/o Candidates	35.85%	38%
Cards with SS Candidates (unverified)	35.05%	42%
Military w/o Candidates	7.99%	6%
<u>NODE 3</u>		
To CSORT	44.72%	43.4%
To Civil File	7.99%	5.4%
To MFPHO/D	35.10%	39.4%
To AUTOCOR	12.20%	11.8%
<u>MISCELLANEOUS</u>		
% of Criminal Cards with FBI #	22%	35.54%
% of total no. of Cards idented	37.66%	37.4%
% of Cards with TS idents (verified) given they had no SS Candidates	5.74%	19.46% *
% of Cards with TS idents (unverified) given they had no SS Candidates	N.A.	28.46%
% of Civil Cards with SS Candidates (verified)	8.66%	10.64% *
% of Civil Cards with SS Candidates (unverified)	N.A.	15.56%
% of Criminal Cards with SS Candidates (verified)	59.49%	47.87% *
% of Criminal Cards with SS Candidates (unverified)	N.A.	70%
% of Criminal Cards in the mix of civil and Criminal Cards that go to Subject Search	52%	49.56%

\*Assuming a false drop rate of 31.63%

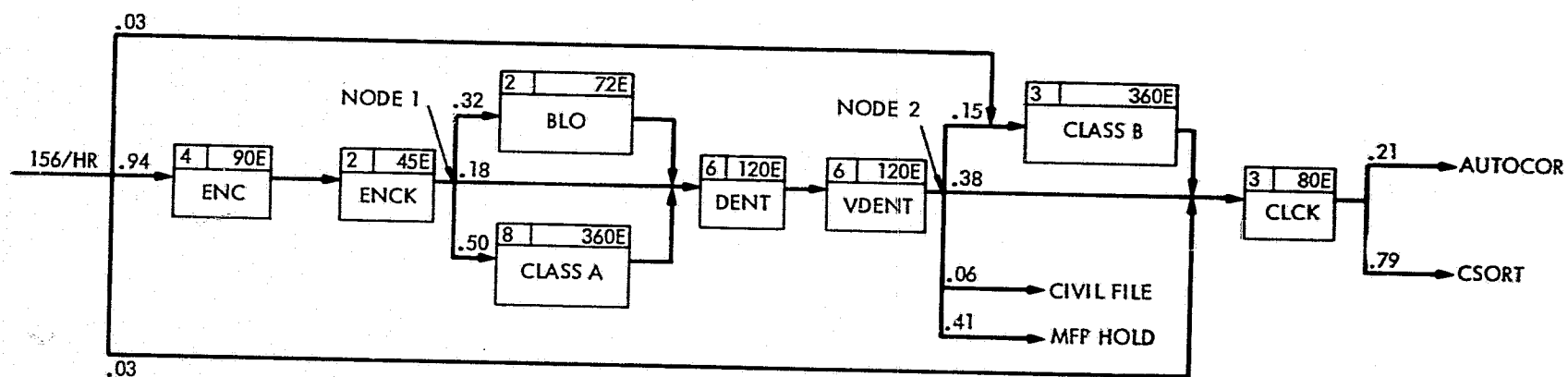


Figure 4. Work Cell Model

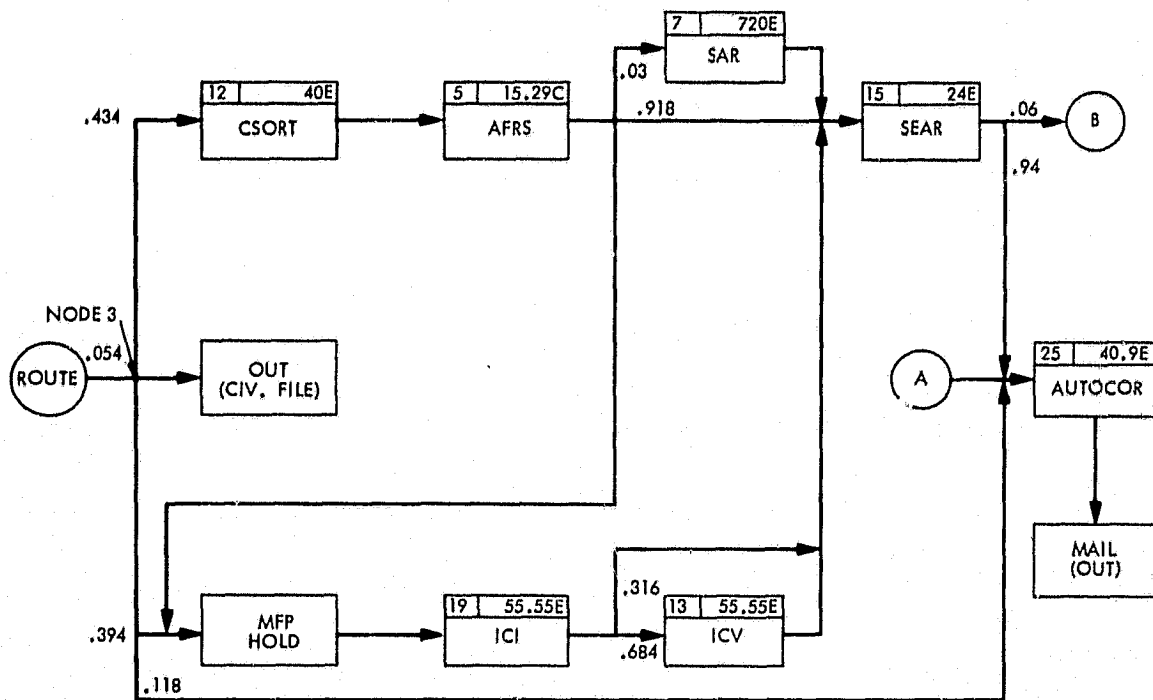
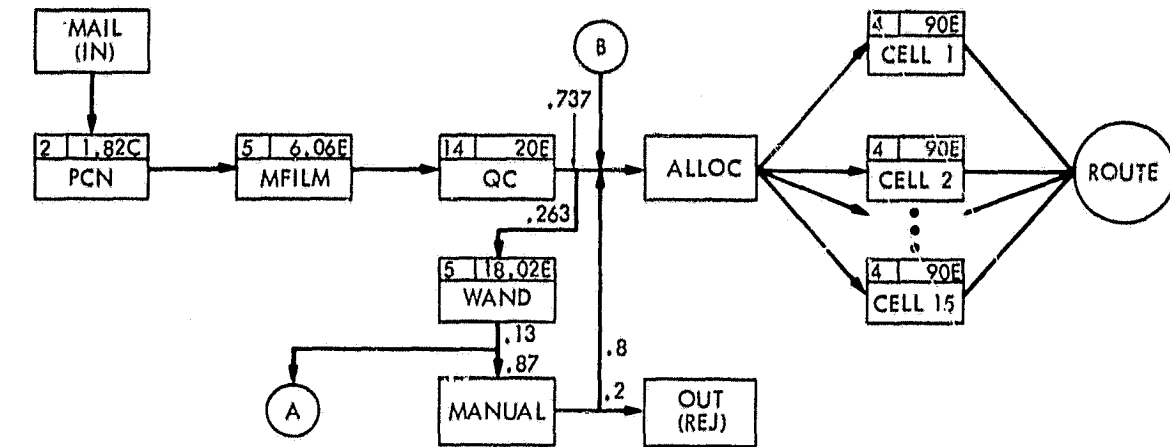


Figure 5. GPSS Simulation Model

Applying these results to the Operating Concept Chart:

(1) Civil cards:

Of the 852 cards/hour without SS candidates, 15% (see Rockwell Technical Memo 080-010, page 5, item #5) are illegible.

$$852 - 852 \times \frac{16}{100} = 716 \text{ cards/hour}$$

.7% of 716 = 5 civil cards/hour identified in TS (verified).

(2) Criminal Cards:

Of the 335 cards without SS candidates, 30% (see Rockwell Technical Memo 080-010, page 5, item #5) are illegible.

$$335 - 335 \times \frac{30}{100} = 234 \text{ cards/hour}$$

15% of 234 = 35 criminal cards/hour identified in TS (verified)

The total number of cards identified and verified in TS (with no SS candidates) according to the success rates deduced from the Design Guideline is  $35 + 5 = 40$  cards/hour.

In Figure I-6 we see that, according to the Operating Concept Chart, there are 294 cards/hour for which TS has found (but not verified) candidates.

Combining both results:

$$\frac{294-40}{294} \times 100 = 86\% \text{ false drop rate in TS!}$$

This surprising result shows, again, an inconsistency between the work load values under consideration as they appear in both charts.

We find in Table I-1 that the percentage of cards with (unverified) TS identifications and no SS candidates is 28.46%. This is much too high, confirming the inconsistency of some figures in both charts.

Work Loads Used in the Simulation Model:

The work load information provided in the Identification Division Guidelines is not enough to create an AIDS III model that can be used in the simulation. The Rockwell Operating Concept Chart contains a study of AIDS III work loads that is more comprehensive. It contains additional information that was obtained from outside sources and direct measurements, and is a consistent set of numbers in itself.

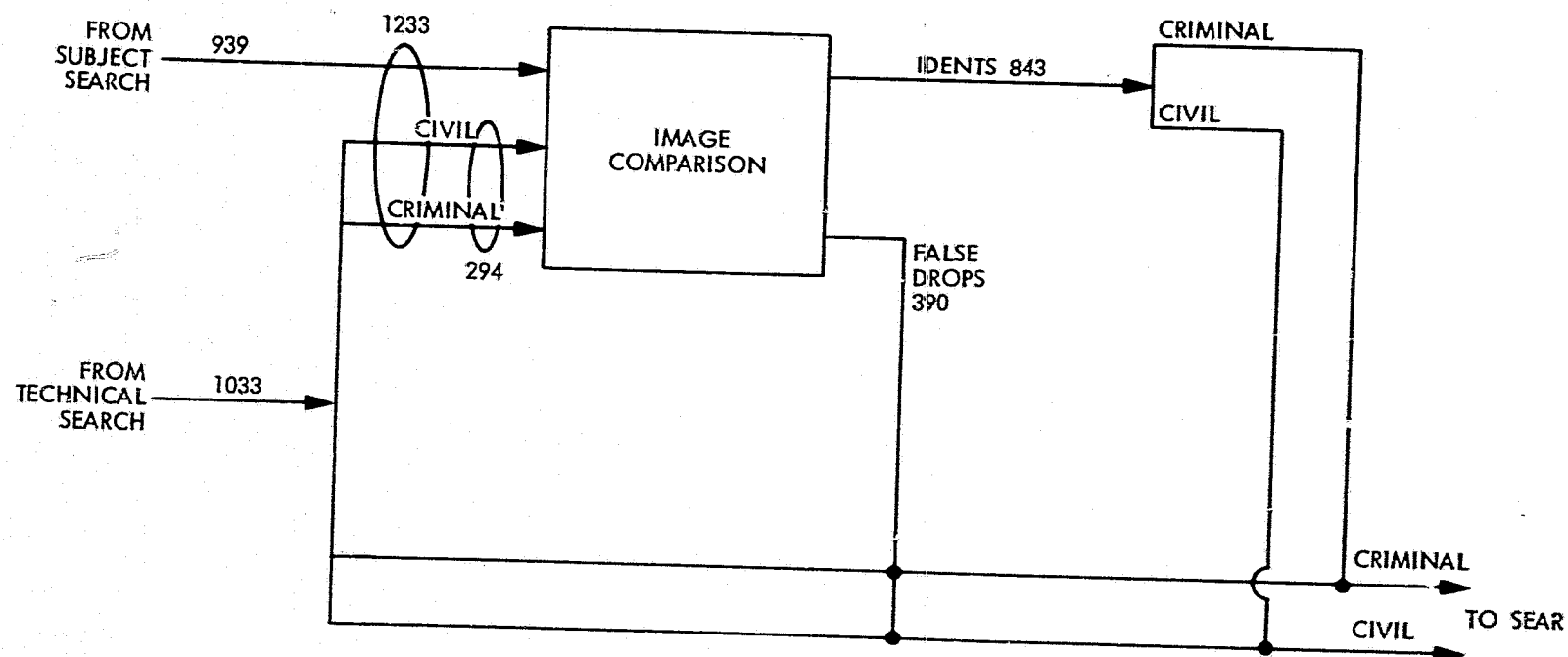


Figure 6. Candidate Verification Drop Rate

For these reasons, the work loads in the computer model utilized for the simulation studies were either taken directly from the Rockwell Operating Concept Chart or were derived from it.

By way of reference, a listing of the calculations made to create Table I-1 is given below.

A. PRE-SEARCH (NODE 1):

1. Design Guidelines:

Input to node:  $13840 + 12769 = 26609$  Cards

(a) Full Classification (Civil & Military Cards):

$$\frac{12769}{26609} \times 100 = 47.99\%$$

(b) Blocking Out (Criminal Cards w/o FBI number):

$$\frac{10796}{26609} \times 100 = 40.57\%$$

(c) Criminal Cards with FBI number:

$$\frac{3045}{26609} \times 100 = 11.44\%$$

2. Operating Concept Chart:

(a) All values are taken directly from the Chart.

B. SUBJECT SEARCH (NODE 2):

1. Design Guidelines:

(a) Criminal Cards w/o SS Candidates:

$$\frac{5609}{26609} \times 100 = 21.08\%$$

(b) Civil Cards w/o SS Candidates:

$$\frac{9538}{26609} \times 100 = 35.85\%$$

(c) Military Cards w/o SS candidates:

$$\frac{2125}{26609} \times 100 = 7.99\%$$

(d) Cards with SS candidates (unverified):

This information is not available in the Design Guidelines chart. Inasmuch as the sum of all four branches of this node must be 100, the percentage for this branch is:

$$100 - (21.08 + 35.85 + 7.99) = 35.08\%$$

2. Operating Concept Chart:

(a) All values are taken directly from the chart.

C. POST-SEARCH (NODE 3):

1. Design Guidelines:

(a) To CSORT (Subject Search Non-Indents)

$$(9538 + 5609 - 1568 - 1679) = 11900$$

$$\frac{11900}{26609} \times 100 = 44.72\%$$

(b) To Civil File (Military Non-Ident)

$$\frac{2125}{26609} \times 100 = 7.99\%$$

(c) To MFPHOLD (Subject Search Idents):

$$3045 + 5118 + 1106 = 9339$$

$$\frac{9339}{26609} \times 100 = 35.10\%$$

(d) To AUTOCOR (Illegibles):

$$\frac{1568+1679}{26609} \times 100 = 12.20\%$$

2. Operating Concept Chart:

Input to Node: A feedback loop sends a total of  $60 + 68 = 128$  cards back to Technical Search from SEAR. In the Cell Model, this feedback loop (point B in Segment 1 of Figure 5) reenters at the cell input. The system that is being modeled includes the cell concept; thus, the input to NODE 3 that is used for the calculations is:

$$2254 + 128 = 2382 \text{ cards/hr.}$$

(a) To CSORT (Subject Search Non-Idents):

$$\frac{1033}{2382} \times 100 = 43.4\%$$

(b) To Civil File (Military Non-Ident):

$$\frac{128}{2382} \times 100 = 5.4\%$$

(c) To MFPOLD (Idents):

$$\frac{939}{2382} \times 100 = 39.4\%$$

(d) To AUTOCOR (Illegibles):

$$\frac{282}{2382} \times 100 = 11.8\%$$

D. MISCELLANEOUS:

1. Design Guidelines:

(a) % of Criminal Cards with FBI number:

$$\frac{3045}{13840} \times 100 = 22\%$$

(b) % of total number of Cards identified:

$$\frac{3045+5188+1106+625+58}{13840+12769} \times 100 = 37.66\%$$

(c) % of Cards with TS idents (verified) given they had no SS Candidates:

$$\frac{625+58}{9538+5609-1568-1679} \times 100 = 5.74\%$$



- (d) % of Cards with TS ident's (unverified) given they had no SS Candidates:

The Design Guidelines do not include the Image Comparison (verification) Function with the False drop rates.

- (e) % of Civil Cards with Subject Search Candidates (verified) :

$$\frac{1106}{12769} \times 100 = 8.66\%$$

- (f) % of Civil Cards with SS Candidates (unverified):

All figures in the Design Guidelines are for verified ident's only. Unverified ident's do not appear in the work load chart.

- (g) % of Criminal Cards with SS candidates (verified):

$$\frac{3045+5188}{13840} \times 100 = 59.49\%$$

- (h) % of Criminal Cards with SS Candidates (unverified):

Not available from the chart.

- (i) % of Criminal Cards in the mix of Civil and Criminal Cards that go to Subject Search:

$$\frac{1230}{1230+1135} \times 100 = 52\%$$

## 2. Operating Concept Chart:

The Operating Concept Chart contains information about the false drop rates in the form of a uniform ratio in the mix of Civil and Criminal Cards for which Subject Search or Technical Search has found potential candidates. From the information in the Chart, the percentage of the card mix verified as ident's in Image Comparison is:

$$\frac{843}{1233} \times 100 = 68.37\%$$

This result has been used in the Table to calculate the percentages of verified ident's for the Operating Concept Chart column for both Civil and Criminal Cards with Candidates from the searches.

- (a) % of Criminal Cards with FBI number:

$$\frac{397}{397+720} \times 100 = 35.54\%$$

(b) % of total number of Cards idented:

$$\frac{843}{2254} \times 100 = 37.4\%$$

(c) % of Cards with TS idents (verified) given they had no SS Candidates. In Figure 6:

$$1233 - 939 = 294 \text{ Cards with Candidates (unverified)}$$

$$68.37\% \text{ of } 294 = 201$$

$$\frac{201}{1033} \times 100 = 19.46\%$$

(d) % of Cards with TS idents (unverified) given they had no SS candidates:

From Figure 5:

$$1233 - 939 = 294$$

$$\frac{294}{1033} = 28.46\%$$

(e) % of Civil Cards with Subject Search Candidates (verified):

Civil cards with SS Candidates:

$$1137 - 128 - 852 = 157$$

$$\frac{157}{1137-128} \times 100 = 15.56\% \text{ (unverified)}$$

$$68.37\% \text{ of } 15.56 = 10.64\%$$

(f) % of Civil Cards with SS Candidates (unverified):

From above: 15.56%

(g) % of Criminal Cards with SS Candidates (verified):

Criminal Cards with SS Candidates:

$$397 + 720 - 335 = 782$$

$$\frac{782}{397+720} \times 100 = 70\% \text{ (unverified)}$$

$$68.37\% \text{ of } 70 = 47.87\%$$

(h) % of Criminal Cards with SS Candidates (unverified):

From above: 70%

- (i) % of Criminal Cards in the mix of Civil and Criminal Cards that go to Subject Search.

$$\frac{1117}{1117+1137} \times 100 = 49.56\%$$

## APPENDIX J

### ACRONYMS

ACS	Automated Classification System
AFRS	Automated Fingerprint Reader System
AHU	Anti-Halation Underlayer
ATDS	Automated Identification Division System
ANS	Automated Name Search
ATS	Automated Technical Search
ATSPS	Automated Technical Search Pilot System
AUTOCOR	Automated Correspondence Station (part of AIDS)
AUTORESP	Automated Response Generation (part of AIDS)
A&R	Automation and Research Section of Identification Division
BER	Bit Error Rates
BLO	Blocking Out
CCA	Computerized Contributor Abbreviated Name
CCH	Computerized Criminal History (part of NCIC)
CCN	Computerized Criminal Name
CCNR	Computerized Criminal Name and Record (part of AIDS)
CCR	Computerized Criminal (Arrest) Record (part of AIDS)
CIR	Computerized Ident Response File (part of AIDS)
CLASS-A	Classification-A
CLASS-B	Classification-B
CLASS-C	Classification-C
CLCK	Classification Check
CNR	Computerized Non-Ident Response File
COA	Cutoff Age
CPU	Central Processing Unit

CRS	Computerized Record Sent File (part of AIDS)
CRT	Cathode Ray Tube
CSORT	Centerline Sort
DATE STP	Date Stamp, Count and Log
DBMS	Data Base Management System
DEDS	Data Entry and Display Subsystem (part of AIDS III)
DENT	Data Entry
DENT-A	Data Entry-Cards
DENT-B	Data Entry-Documents
DOA	Date of Arrest (on f/p card)
DOB	Date of Birth (on f/p card)
ECL	Emitter Coupled Logic
EMI	Electromagnetic Interference
ENG	Encode Input Data-Cards
ENGDOC	Encode Input Data-Documents
ENCK	Encode Check-Cards
ENDOCK	Encode Check-Documents
ERR	Update Error File
EYE	Color of Eyes (on f/p card)
FBI	Federal Bureau of Investigation
FEP	Front End Processor
FIFO	First-In-First-Out
FLAB	Film Lab Processing/Computer
FLOAD	Film Load
FPC	Fingerprint Classification
FPCS	Fingerprint Correspondence Section of the Identification Division
f/p	Fingerprint

GDBMS	General Purpose Data Base Management System
GEO	Geographic Location (on f/p card)
GPSS	General Purpose Simulation System
HAI	Color of Hair (on f/p card)
HGT	Height (on f/p card)
IBM	International Business Machines Corporation
ICI	Image Comparison Identification
ICRQ	Image Comparison Request
ICS	Image Comparison Subsystem (part of AIDS III, actually used for image retrieval for manual comparison)
ICV	Image Comparison Verification
ID, I.D.	Identification Division
IDENT	Identification
JPL	Jet Propulsion Laboratory
KIPS	Thousands of Instructions per Second (as executed by a computer)
LEAA	Law Enforcement Assistance Agency
MAIL	Open Mail and Sort
MFILM	Image Capture Microfilm
MIPS	Millions of Instructions per Second (as executed by a computer)
MMF	Minutiae Master File
MOE	Measures of Effectiveness
MTBF	Mean Time Between Failures
MTR	Master Transaction Record
MTTR	Mean Time to Restore
NAM	Name (on f/p card)
NASA	National Aeronautics and Space Administration
NCIC	National Crime Information Center

NCR	National Cash Register Company
OCA	Local Identification Number (on f/p card)
OCR	Optical Character Recognition
OMB	Office of Management and Budget
ORI	Originating Agency Identification Number (on f/p card)
PCN	Process Control Number
PICS	PCN and Image Capture Subsystem (part of AIDS III)
PMT	Photomultiplier Tubes
POB	Place of Birth (on f/p card)
QC	Quality Control
QUERY	On-Line Query
RAC	Race (on f/p card)
READ	Quality Control Check, Read, Annotate
RFI	Radio Frequency Interference
RH	Relative Humidity
RVF	Ridge Valley Filter
SACS	Semi-Automatic Classification System
SAR	Semi-Automatic Fingerprint Reader
SEAR	Search Review
SEX	Reported Sex of a Subject (on f/p card)
SID	State Identification Number
SKN	Skin Tone (on f/p card)
SOC	Social Security Number (on f/p card)
SPM	Search Processor Module
SS	System Supervisor Subsystem (part of AIDS III)
SSM	Subject Search Module
SSRG	Subject Search and Response Generation Subsystem (part of AIDS III)

TDFA	Top Down Functional Analysis
TFC	Technical File Conversion
TR	Transaction Record
TRC	Transaction Control File
TSS	Technical Search Subsystem (part of AIDS III)
TTL	Transistor - Transistor Logic
VDENT-A	Verify Data Entry-Cards
VDENT-B	Verify Data Entry-Documents
VLSI	Very Large Scale Integration
WAND	Wand Out of System